AN ABSTRACT OF THE THESIS OF

Stanley Glade Miller for the degree of Master of Science in Industrial Engineering presented on May 3, 1996. Title: Out of Service Criteria for Commercial Vehicles: Evaluation of Accident Data in Relation to Vehicle Criteria.

Abstract approved: Redacted for Privacy

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The Commercial Vehicle Safety Alliance (CVSA) is an association of industry representatives, and state, territorial, provincial, and federal government officials in the United States, Canada, and Mexico. The CVSA's goal is to improve commercial vehicle safety. The CVSA concentrates its safety focus on three areas; driver, vehicle, and hazardous materials. Since 1981, the CVSA has developed a set of criteria for each of the three areas that define conditions which are so unsafe that a truck and/or driver should not be allowed to operate. These criteria are known as out of service (OOS) criteria.

To check the compliance of motor carriers with the CVSA criteria, a series of road side inspections is conducted by state and local governments. If the driver and/or vehicle are found in violation of the CVSA OOS criteria, they are placed "out of service" until the conditions are completely remedied.

Due to criteria growth, the CVSA wanted to examine the OOS criteria in the vehicle and hazardous materials areas.

This study, focused on the vehicle portion of the OOS criteria, attempted to correlate commercial vehicle defects to commercial vehicle accidents. For a major

portion of this project, actual accident reports from six states of the United States were evaluated. The states and reports were selected via a stratified two stage cluster sampling system. The results were used to form estimates of the proportion and number of commercial vehicle accidents in the United States with a mechanical defect as a contributing factor.

In addition to the accident report sampling, other sources were used to establish a correlation between vehicle defects and commercial vehicle accidents. They include literature, national databases, and post-crash inspections.

Results from this study show that approximately 4.6% of all commercial vehicle accidents have a mechanical defect as a factor contributing to the accident. Of these, brakes (1.66%), tires (0.45%), couplings (0.38%), load securement (0.37%), and wheels (0.33%) accounted for the majority. A comparison was also made between the OSU study results and the information gathered from other sources.

A cost factor was also used to rank the accidents. The sampled accidents accrued $22.7 million in damage to people and property.

The underlying assumption is vehicle defects that are strongly represented in accidents and accident damage estimates should have a strong representation in the out-of-service criteria.

Out-of-Service Criteria for Commercial Vehicles: Evaluation of Accident Data in Relation to Vehicle Criteria

by

Stanley Glade Miller

in partial fulfillment of
the requirements for the
degree of

Master of Science

Completed May 3, 1996
Commencement June 1997

Master of Science thesis of Stanley Glade Miller presented on May 3, 1996

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Stanley Glade Miller, Author

ACKNOWLEDGMENTS

I would like to thank the following people for their support during this project:

Dr. Randhawa provided excellent support, advice, and funding throughout my Master's program. Thanks also for selecting me for this project even before my acceptance to Oregon State University.

Dr. Bell, the project director, provided support and insight into the nature of participant relationships.

Dr. Lundy installed a realistic focus for project objectives.

Paul Montagne laboriously collected much data for this report through countless telephone and facsimile communications.

Thanks to all the faculty at the Industrial and Civil Engineering Departments.

Special thanks to Dale, my wife and sounding board, for her logic, understanding, and support.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF APPENDICES (continued)

APPENDICES TABLES

APPENDICES TABLES (continued)

APPENDICES TABLES (continued)

ACRONYMS

AIS	Abbreviated Injury System
CMV	Commercial Motor Vehicle
CVSA	Commercial Vehicle Safety Alliance
DCI	Detailed Claim Information
FARS	Fatal Accident Reporting System
FHWA	Federal Highway Administration
GES	General Estimates System
KABCO	Injury Rating Scale found on Police Reports
MAIS	Maximum Abbreviated Injury System
MCS	Motor Carrier Safety
NASS	National Accident Sampling System
NCSA	National Center for Statistics and Analysis
NHSB	National Highway Safety Bureau
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
OOS	Out of Service
OSU	Oregon State University
PAR	Police Accident Report
PDO	Property Damage Only
PJ	Police Jurisdiction

ACRONYMS (continued)

PPS	Probability Proportional to Size
PSU	Primary Sampling Unit
PUC	Public Utilities Commission (Oregon)
TRI	Transportation Research Institute at Oregon State University
UMTRI	University of Michigan Transportation Research Institute
USDOT	United States Department of Transportation

Out-of-Service Criteria for Commercial Vehicles: Evaluation of Accident Data in Relation to Vehicle Criteria

1.0 INTRODUCTION

1.1 Background

The Commercial Vehicle Safety Alliance (CVSA) is an association of industry representatives, and state, territorial, provincial, and federal government officials in the United States, Canada, and Mexico. The CVSA, working with government officials, administers motor carrier safety and hazardous material laws in those countries. The CVSA's goal is to improve commercial vehicle safety. The CVSA's Memorandum of Understanding was summarized in Bell, et al. [1]. The memorandum also appears in Appendix C of that report.

The CVSA has worked continuously since 1981 to develop and maintain out-of-service (OOS) criteria for commercial motor vehicles (CMVs). The OOS criteria are designed to define vehicle and/or driver conditions that constitute an imminent hazard. By definition, this hazard violates federal or state safety regulations and is likely to cause an accident, a breakdown, or a loss of vehicle control that could result in serious injury or death. For criteria concerning hazardous materials, the CVSA focused on conditions that could lead to a hazardous material spill and situations where the cargo's potential hazard is not accurately communicated. By CVSA design, a vehicle/driver combination diagnosed with an OOS condition should be immediately discontinued and remain out-of-service until the problem is remedied.

During criteria development, the CVSA considered the diagnosis method which would detect the OOS conditions. This diagnosis is performed primarily at road-side inspection sites by government inspectors. The OOS criteria, therefore, were restricted to items that were visible and could be easily measured. Time was also a factor and the number of OOS items to be inspected was limited so that each inspection lasted approximately 30 minutes. For information regarding the development of the OOS vehicle criteria, refer to Bell, et al. [1]. Likewise, refer to Bell, et al. [2], for the development of hazardous material criteria.

1.2 Purpose

Since CVSA inception, the number of items that qualify as an OOS condition has increased. Due to this growth, the CVSA decided to examine the criteria for vehicles and hazardous materials. To perform this task, the CVSA contracted with the Oregon Public Utility Commission (PUC). The Oregon PUC then contracted with the Transportation Research Institute (TRI) at Oregon State University (OSU) to conduct a study entitled "A Review of Out of Service Criteria."

The first phase of the project synthesized relevant information regarding the development and justification of OOS criteria for CMVs [1]. A companion report reviewed relevant information for OOS criteria concerning hazardous materials transport [2].

The purpose of this study is to assess the validity of the OOS criteria, as related to commercial vehicles. The OOS criteria were designed to identify imminent hazards which are likely to cause an accident, breakdown, or loss of vehicle control

that could result in serious injury or death. Therefore, this report focused on establishing the relationship between vehicle defects and accidents. The underlying assumption is vehicle defects that have a strong correlation to accidents should have a strong representation in the OOS criteria.

1.3 Scope of Report

After establishing the need to correlate accidents to OOS criteria, a strategy was developed to estimate the proportion of commercial vehicle accidents that have a specific mechanical defect as a contributing factor. The strategy consists of two main components. First, actual accident reports were collected from individual American states and evaluated. Second, information from other sources was evaluated, including, literature, national databases, and post-crash inspections. The national database work was subcontracted to the University of Michigan Transportation Research Institute.

Chapter Two of this report, Accident Report Sampling, discusses the methodology behind OSU's accident report evaluations. Cost Integration, Chapter Three, develops a method of relating accidents to monetary values. Chapter Four, Evaluation of Additional Sources, covers data gathered from national databases and post-crash inspections. Results from the accident sampling study appear in Chapter Five. Chapter Six, Analysis, contains data comparisons, data source analysis, and a discussion of accident data and out of service criteria. Chapter 7, Conclusions and Recommendations, includes conclusions, recommendations, and recommendations for future research.

The appendices contain an overview of the National Accident Sampling System/General Estimates System sampling procedure; databases by state; state proportion and confidence intervals; strata proportion and confidence intervals; national proportion and occurrence estimates (including confidence intervals) from the OSU sampling study; accident inspection databases; additional sources results; and state accident population sources.

2.0 ACCIDENT REPORT SAMPLING

2.1 Study Introduction

The CVSA sponsored much of this report in an effort to assess the validity of the vehicle OOS criteria. Since the OOS criteria are designed to identify imminent hazards, the major focus in the study was to find out what defects actually contributed to accidents.

This report developed a sampling system to find the proportion of commercial vehicle accidents where a specific mechanical defect was listed as a contributing factor. An objective of the sampling system was to infer the results from individual accident reports to the entire United States.

2.2 Study Background

In the effort to analyze accident data, information was collected directly from the states. This method was selected for several reasons. First, the existing national databases contain little information about mechanical defects as contributing to an accident. The national databases rely solely on the authority completing the accident report to check the correct box on the accident report relating to the mechanical defect which contributed to the accident. This report desired to gather more information about the accident than "check-box" reporting provided. The additional information was located in the narrative section of the accident report, which was not typically transferred into national databases. The second concern was that the sources for those databases were not consistent. For example, California accident reports contain four

choices for mechanical defects, while Washington State accident reports allow sixteen. Assimilation into a single national database compromises the data. Third, the bias of different people from different states who translate the accident report into the database is eliminated. Research for this report evaluated all sample data from all locations to remove inconsistent bias. For these reasons, it was decided to review actual accident reports, with emphasis on information found in the narrative sections, to determine what, if any, mechanical defects contributed to the accident.

2.3 Sample Design

For study purposes, estimates for the proportion and number of CMV accidents with a mechanical defect as a contributing factor occurring in the United States were desired. With an estimated 400,000 commercial vehicle accidents reported for 1994 by the United States Department of Transportation (USDOT) National Highway Traffic Safety Administration (NHTSA) [3], a census, or exhaustive sampling system, was not feasible. An alternative was to take a sample of the accident reports from a sample of states.

Accuracy and repeatability were balanced with time and financial constraints when developing the sampling system. After examining various sampling techniques, it was decided to use a stratified two stage cluster sampling method. This ensured that the results would be representative of the entire United States. This system also increased precision (reduced standard errors) when compared to a simple random sampling technique, in addition to providing a means to obtain estimates for the separate strata [4].

The stratum units consisted of the 50 states in America. They were separated into three strata. (See Strata Development, Section 2.10) Two states from each stratum were selected. (See State Selection, Section 2.11) Figure 2.3 illustrates the sampling layout.

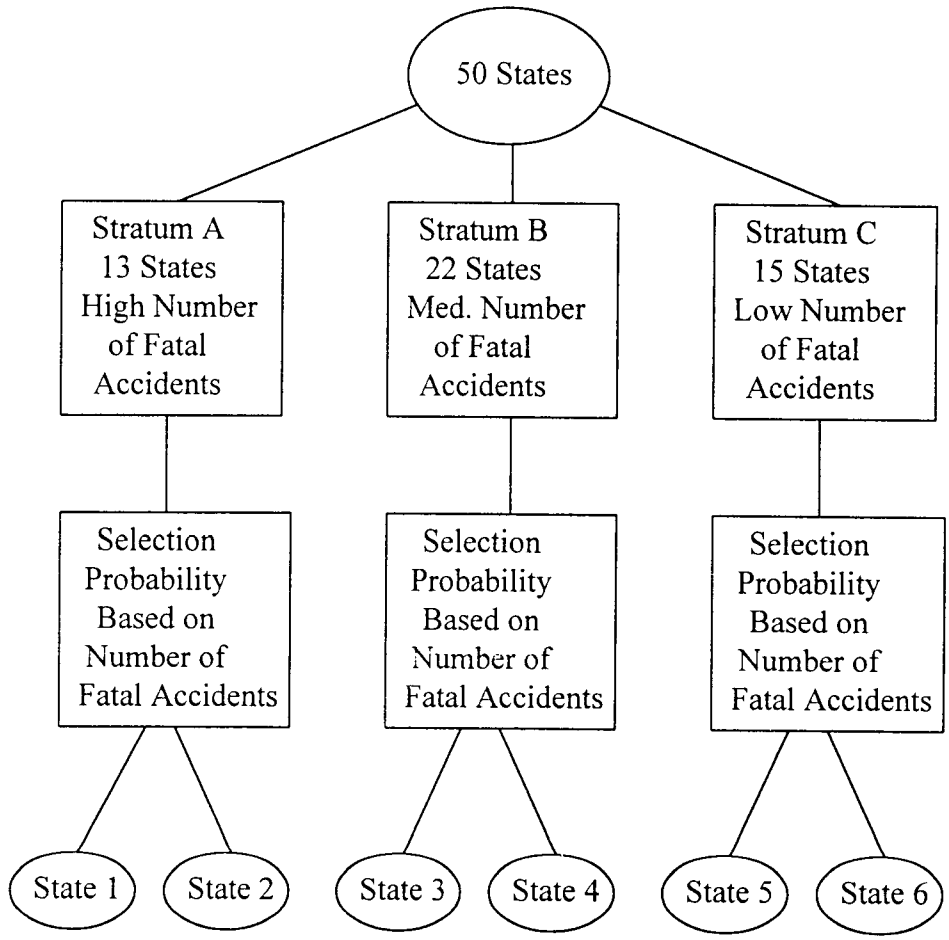

Figure 2.1 Sampling Layout Illustration

2.4 Sample Population

The population of interest was limited to police reported commercial vehicle accidents occurring in the United States in 1993 and 1994. By law, all accidents

causing a death, injury, or certain amount of property damage are required to be reported. In Oregon, Statute 811.720 states that any accident occurring in a highway or upon premises open to the public resulting in injury or death to any person or damages to the property of a person in excess of $500 must be reported [5].

Several studies have estimated the amount of underreporting that occurs depending on the severity of the accident. There is no evidence to suggest that the underreporting for accidents involving mechanical defects differs from all other accidents [6]. Since the primary concern for this report lies with the percentages of accidents that have a mechanical defect as a contributing factor, the underreporting factor was not investigated further.

If the accident caused property damage only (PDO), the dollar value of the damage must reach a certain amount before qualifying as a reportable accident. This amount was not consistent between states. Despite this small inconsistency, this study, like the General Estimate System (GES), uses all of the reported accidents and ignores the threshold value differences in PDO accidents between states. An overview of the sampling process used by the GES is located in Appendix A. The resultant difference between states in number of accidents reported due to variances in crash damage estimates is less pronounced for commercial vehicle accidents than for passenger car accidents. This is attributed to average costs for PDO accidents involving commercial vehicles being higher than PDO accidents for passenger vehicles. Figures published by Miller, et al., indicate property damages for truck accidents were $7,189 more expensive than for other motor vehicles (in 1988 dollars) [6]. As a result, few commercial vehicle accidents would qualify as reportable in one

state and not in another. For these reasons, the threshold value differences between states were ignored, and all police accident reports (PARs) were included in the population for this study.

2.5 Sample Frame

The sample frame is the set of data from which the individual accident reports were collected. Thus, the frame contains all police reported commercial vehicle accidents occurring in the six states selected for sampling (see Section 2.11) in 1993 and 1994. These two years were selected as the most current years available. The report limited the frame to two years due to time and financial constraints.

2.6 Data Collected

Accident reports indicating either a mechanical defect, "other," or "unknown" as a contributing factor were evaluated. The "other" and "unknown" categories often represented mechanical defects that were not represented in check-box form.

The primary indication was made in the standard check-box portion of the accident report. This resulted from a screening process performed by state personnel in the selected state. The screening, based solely on check-box information in the state's computer database, drastically reduced the number of accident reports evaluated for this report. If a "trigger" box was checked, the report, with an emphasis on the narrative section, was evaluated. In this manor, information was taken from both the standard and narrative portions of the report.

The report utilized some general rules for the acceptance of PARs into the database. First, the defect had to contribute to the accident. For example, a report indicating that the CMV was cited for worn tires was not included if it was struck by another vehicle while stopped at a traffic signal.

A more difficult topic was vehicle breakdowns. A cause and effect approach was adopted. This report includes accidents which were indirectly caused by a vehicle defect. Thus, if a car collided with a CMV due to a defect on the CMV, the accident report was included. This included trucks stopped due to a mechanical defect. The main question before inclusion was, "Would the accident have occurred if the defect had not been present?"

Data recorded from the accident reports includes: state, date, report number, truck type, listed defect #1, listed defect #2, and listed defect #3, specific sub-item, injury #1 severity, injury #2 severity, injury #3 severity, and researcher notes from the narrative.

2.7 Sample Parameters

Fundamental to the study design was the calculation of sample size. Accuracy and reliability levels were balanced with time and financial constraints. Not surprisingly, increases in accuracy and repeatability resulted in increased sample size. The time and financial requirements rose directly with the sample size.

The accuracy level, designated ε, represents the comparison between the estimated population proportion, $\hat{P}$, and the true population proportion. The sample

size, as calculated in Section 2.12, was highly dependent on ε. Values between 0.38 and 0.40 satisfactorily balanced the accuracy and time and financial constraints. A value of 0.386 was chosen as it resulted in the round number of 3,600 for the sample size. The value of 0.386 indicates that the $\hat{P}$ for a specific mechanical defect should be within 38.6% of the true proportion.

The reliability coefficient represents the percentage of identical studies that the $\hat{P}$ is expected to be within the above 38.6% range. This report utilizes a 90% reliability factor. The reliability coefficient is a compromise between reliability and time and financial constraints.

Therefore, if an identical study was repeated 10 times, the true value is expected to be within 38.6% of the estimated value 9 times. For example, if widget defects contributed to 5% of all CMV accidents, 90% of the studies would indicate that widget defects contributed to between 3.07% and 6.93% of all CMV accidents.

Also critical to the sampling system is the original estimation of the population proportion that has a mechanical defect as a contributing factor. This report utilizes a value of 0.5% (0.005). The 0.5% value allows the study to discriminate between types of defects. While the overall percentage of accidents with a mechanical defect as a contributing factor was estimated at around 5%, the sampling study desired to break the defects into categories. In order to get accurate and reliable information about the individual defect categories, the sampling system was forced to

utilize a value much smaller than the overall 5% estimate. The 0.5% value for this variable was based on a review of two previous studies.

Although the studies were independent, both relied on the United States Department of Transportation Federal Highway Administration (USDOT/FHWA) Motor Carrier Safety (MCS) database. This database, discontinued in 1992, contained more detailed information about commercial vehicle accidents and mechanical defects than any other national database. The first report, "Are Safety Inspections Doing Their Job?" by Douglass, et al., covered 165,189 accident reports submitted to the MCS database by the involved motor carriers [7]. The Douglass report listed percentages for defects, even if only one was found. The second study, 1976-1978 Analysis of Motor Carrier Accidents Involving Vehicle Defects or Mechanical Failure, performed by the Bureau of Motor Carrier Safety, summarized all accidents reported to them under the provisions of Part 394 of the Federal Motor Carrier Safety Regulations (Code of Federal Regulations, title 49) for three years [8]. That study listed all reported defects, even if only one defect of a certain type was found.

Although the above studies were exhaustive and not based on sampling, the findings indicated that the majority of mechanical defect related accidents fall into a few broad categories. The studies also indicated that each of these dominant defect categories accounted for approximately 0.5% or more of the accident population. Based on these publications, a 0.5% proportion estimate for CMV accidents involving a mechanical defect was used for this report.

As a note, no attempt was made to draw inference for the entire United States in either of the two previously mentioned studies. The studies simply reported what was recorded in the particular database. For this reason, the studies were not concerned with accuracy levels, reliability coefficients, estimated proportions, or sample sizes.

2.8 Sampling Distribution

By definition, this sampling procedure is a binomial experiment. The requirements for a binomial experiment are [9]:

1) The experiment consists of a fixed number of trials (fixed sample size).

2) The trials are identical, each having a possible "yes" or "no" result.

3) The trials are independent.

4) The probability of a positive or "yes" response is consistent for all trials.

2.9 Confidence Intervals

As an indication of reliability, it was desired to establish confidence intervals for the resultant estimated proportion and number of accidents with a mechanical defect as a contributing factor occurring in the United States. A frequently used confidence interval of 90% was chosen. Therefore, an identical study would produce a result inside the confidence interval in 9 out of 10 times.

Given a binomial sample distribution, the F distribution can be utilized to establish expressions for the upper and lower values of $\hat{P}$ [10]. Letting n equal the sample size, and X equal the number of positive responses,

the equation for a 90% confidence interval for $\hat{P}$ is [10]:

Upper confidence limit = $$\frac{(X+1)\times F_{(1-.90)/2,2(X+1),2(n-X)}}{(n-X)+(X+1)\times F_{(1-.90)/2,2(X+1),2(n-X)}}$$

Lower confidence limit = $$\frac{X}{X+(n-X+1)\times F_{(1-.90)/2,2(n-X+1),2(X)}}$$

The confidence limits are designed for a simple random sampling plan. They will be slightly conservative for this study which utilizes a stratified two stage cluster design.

2.10 Strata Development

Ideally, the sample system design would have divided the states into categories, or strata, depending on the population of police reported commercial vehicle accidents. However, the number of accidents per state was not available. The total number of police reported accidents for all of the states combined can be found as an estimate performed by the General Estimate System (GES). An overview of the sampling process used by the GES is found in Appendix A.

In order to stratify the states, the report relied on data recorded in the Fatal Accident Recording System (FARS). The FARS is a census in which detailed information about fatal motor vehicle accidents occurring in the United States is recorded. The use of FARS data for stratification purposes required one large assumption. The report assumed that the ratio of police reported commercial vehicle accidents to fatal commercial vehicle accidents to be constant between the states. In

short, it was assumed that a state demonstrating a high number of commercial vehicle fatality accidents had a proportionally high number of police reported commercial vehicle accidents.

A similar stratification process was performed for the GES. That system utilized fatalities and injuries to stratify sampling units of similar human population.

The states were divided into three categories, or strata, based upon the number of fatality CMV accidents occurring over a two year period. The breaks between strata were seen as natural separations in the FARS data. A two year period was chosen for two reasons. First, an abnormally high (or low) number of fatalities for any one year could alter the stratification, especially for the states with relatively few commercial vehicle fatalities. Second, as the study encompassed 1993 and 1994, using 1993 and 1994 FARS data maintained consistency between stratification and accident sampling.

The first strata consisted of the top 13 states, in terms of fatal CMV accidents; the second strata consisted of the mid 22 states; and the third strata consisted of the bottom 15 states. Again, the stratification was based entirely on the FARS data. Table 2.1 shows the rank, strata, and percentages of states based on the FARS data for 1993 [11] and 1994 [12].

Consideration was given to alternative methods for stratification, notably stratification based on geography. However, it was very difficult to divide the states into homogenous regions with this method.

Table 2.1 Strata Definition

Rank	Strata	State	1993 FARS	1994 FARS	Combined	Percentages
1	1	California	344	350	694	7.77
2	1	Texas	347	332	679	7.60
3	1	Florida	287	287	574	6.43
4	1	Pennsylvania	192	203	395	4.42
5	1	Ohio	188	195	383	4.29
6	1	North Carolina	197	185	382	4.28
7	1	Georgia	160	193	353	3.95
8	1	New York	139	191	330	3.69
9	1	Illinois	153	168	321	3.59
10	1	Alabama	149	151	300	3.36
11	1	Michigan	114	173	287	3.21
12	1	Indiana	133	141	274	3.07
13	1	Tennessee	123	136	259	2.90
14	2	Missouri	101	128	229	2.56
15	2	Virginia	91	125	216	2.42
16	2	Kentucky	101	93	194	2.17
17	2	Wisconsin	90	103	193	2.16
18	2	Louisiana	83	109	192	2.15
19	2	Arkansas	102	85	187	2.09
20	2	South Carolina	91	88	179	2.00
21	2	Mississippi	81	85	166	1.86
22	2	Iowa	84	75	159	1.78
23	2	Oklahoma	83	72	155	1.74
24	2	Arizona	68	79	147	1.65
25	2	New Jersey	71	72	143	1.60
26	2	Minnesota	63	75	138	1.55
27	2	Oregon	62	63	125	1.40
28	2	Maryland	47	74	121	1.35
29	2	Kansas	65	51	116	1.30
30	2	Washington	61	53	114	1.28
31	2	Colorado	56	55	111	1.24
32	2	Nebraska	57	44	101	1.13
33	2	West Virginia	41	57	98	1.10
34	2	Massachusetts	34	41	75	0.84
35	2	New Mexico	35	37	72	0.81
36	3	Nevada	25	28	53	0.59
37	3	Utah	26	27	53	0.59
38	3	Connecticut	26	26	52	0.58
39	3	Idaho	10	37	47	0.53
40	3	Maine	21	20	41	0.46
41	3	Delaware	21	12	33	0.37
42	3	Wyoming	12	20	32	0.36
43	3	South Dakota	17	15	32	0.36
44	3	Montana	12	17	29	0.32
45	3	North Dakota	17	9	26	0.29
46	3	Vermont	13	10	23	0.26
47	3	New Hampshire	8	8	16	0.18
48	3	Rhode Island	8	6	14	0.16
49	3	Hawaii	6	4	10	0.11
50	3	Alaska	3	5	8	0.09
		TOTAL	4318	4613	8931	100.00

Source: Traffic Safety Facts 1993, Large Trucks and Traffic Safety Facts 1994, Large Trucks. Published by USDOT NHTSA.

2.11 State Selection

This report utilized a probability proportional to size (PPS) method to select states from each stratum. With this strategy, the probability that a state is selected for sampling is proportional to the number of fatal commercial vehicle accidents that occurred in that state during 1993 and 1994. This plan accommodates the sample population range between states within a stratum. In addition, the PPS method increases the reliability of the sampling system over the reliability of a system relying on simple random sampling [4].

Like the stratification process, the state selection process relied on the assumption that states recording a large (or small) number of commercial vehicle fatality accidents had a proportionally large (or small) number of police reported commercial vehicle accidents. For actual state selection, the PPS strategy relied on the FARS data and a random number generator. The number of fatality accidents from each state was listed and accumulated for the strata. To select a state, a random number generator produced a number between 0 and the total accumulate for the strata. The resultant number indicated the selection of one state.

Table 2.2 shows the states and random number range associated with each state in Strata 1. Figure 2.2 illustrates this selection procedure graphically. Each state had a known and non-zero chance of being selected proportional to the number of fatal commercial vehicle accidents reported [4]. Table 2.3 and Figure 2.3 represent Strata 2, while Table 2.4 and Figure 2.4 represent Strata 3.

Table 2.2 **State Selection for Stratum 1**

State	Random Number Range	
	From	To
California	0	694
Texas	695	1,373
Florida	1,374	1,947
Pennsylvania	1,948	2,342
Ohio	2,343	2,725
North Carolina	2,726	3,107
Georgia	3,108	3,460
New York	3,461	3,790
Illinois	3,791	4,111
Alabama	4,112	4,411
Michigan	4,412	4,698
Indiana	4,699	4,972
Tennessee	4,973	5,231

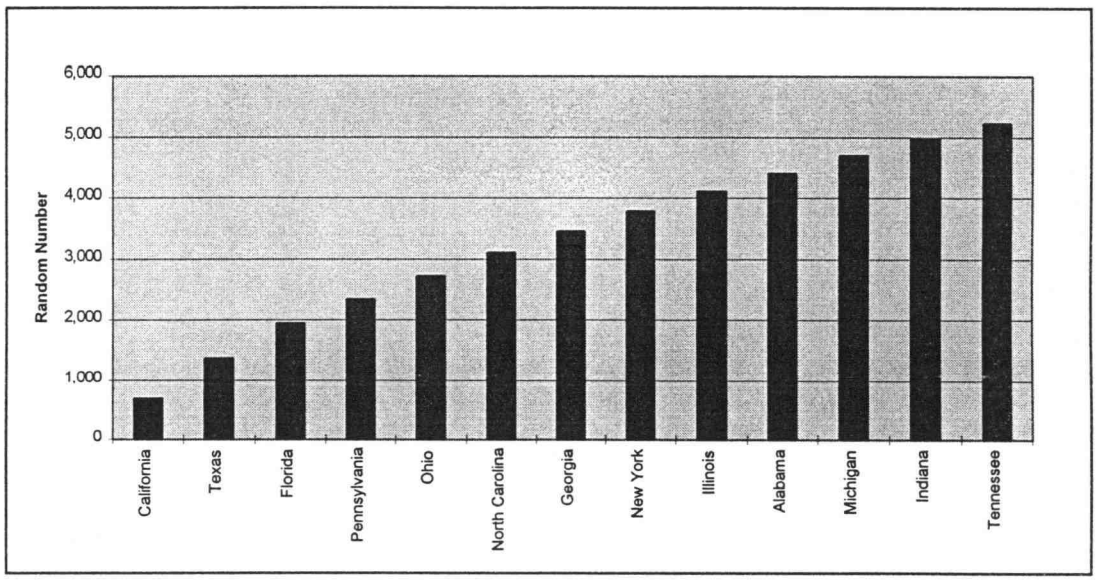

Figure 2.2 **State Selection for Stratum 1**

The two states selected from Stratum 1 were Florida and Ohio.

Table 2.3 State Selection for Stratum 2

State	Random Number Range	
	From	To
Missouri	0	229
Virginia	230	445
Kentucky	446	639
Wisconsin	640	832
Louisiana	833	1,024
Arkansas	1,025	1,211
South Carolina	1,212	1,390
Mississippi	1,391	1,556
Iowa	1,557	1,715
Oklahoma	1,716	1,870
Arizona	1,871	2,017

State	Random Number Range	
	From	To
New Jersey	2,018	2,160
Minnesota	2,161	2,298
Oregon	2,299	2,423
Maryland	2,424	2,544
Kansas	2,545	2,660
Washington	2,661	2,774
Colorado	2,775	2,885
Nebraska	2,886	2,986
West Virginia	2,987	3,084
Massachusetts	3,085	3,159
New Mexico	3,160	3,231

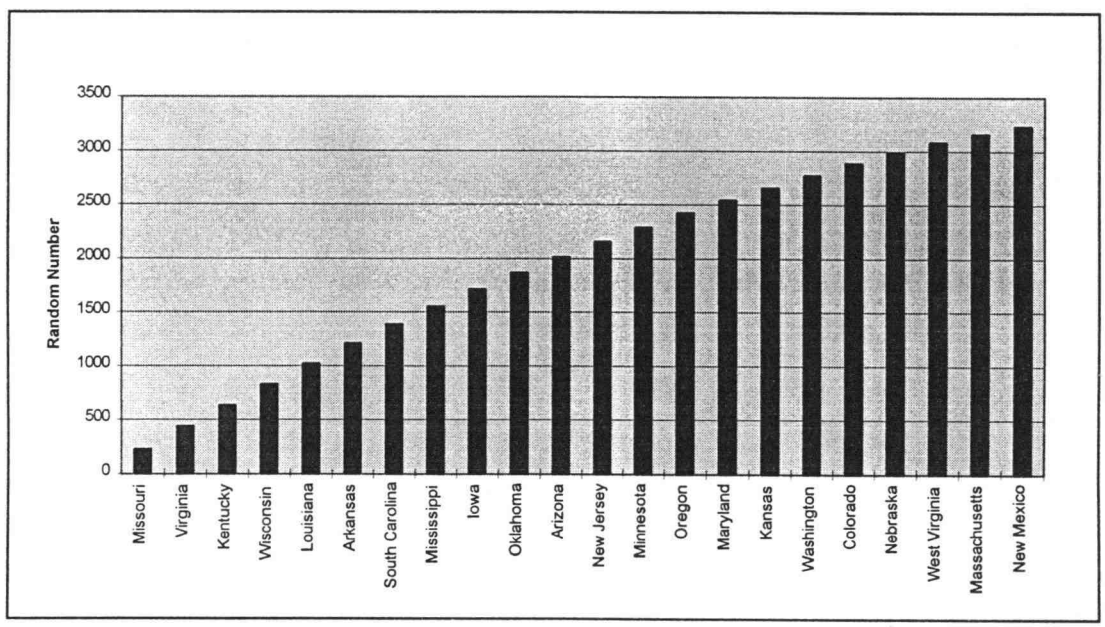

Figure 2.3 State Selection for Stratum 2

The two states selected from Stratum 2 were Missouri and Washington.

Table 2.4 State Selection for Stratum 3

State	Random Number Range	
	From	To
Nevada	0	53
Utah	54	106
Connecticut	107	158
Idaho	159	205
Maine	206	246
Delaware	247	279
Wyoming	280	311
South Dakota	312	343
Montana	344	372
North Dakota	373	398
Vermont	399	421
New Hampshire	422	437
Rhode Island	438	451
Hawaii	452	461
Alaska	462	469

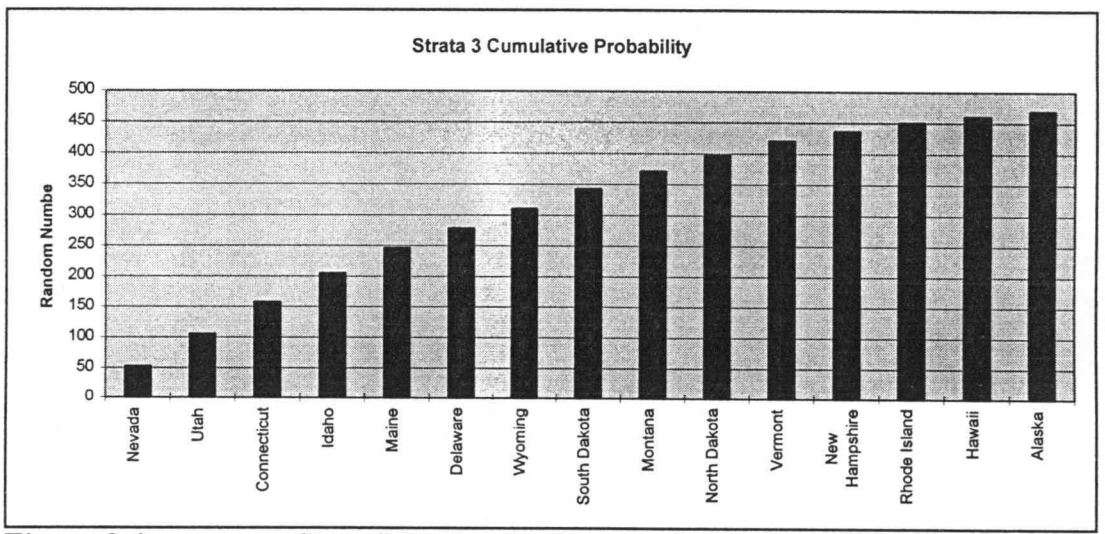

Figure 2.4 State Selection for Stratum 3

The two states selected from Stratum 3 were Idaho and Delaware.

2.12 Sample Size Determination

Given the study parameters listed in Section 2.7 and a stratified random sampling procedure, calculation of the sample size was straightforward. Sample size (n) was determined from the following formula [4]:

$$n = \frac{z^2 \times N \times \hat{P} \times (1 - \hat{P})}{(N-1) \times e^2 \times \hat{P} + z^2 \times \hat{P} \times (1 - \hat{P})}$$

where:

z = Reliability coefficient (1.96 for 95%, 1.65 for 90%)

N = Population Size

ε = Accuracy Range. The sample estimate should not differ in absolute value from the true unknown population by more than [ε *(sample estimate)]

$\hat{P}$ = Unknown population proportion

This study assigned the following values for the above variables:

z = 1.65

N = 395,000

ε = 0.386

$\hat{P}$ = 0.5%

The above formula indicates sample size (n) of 3,600.

After determining the states to be sampled and the overall sample size, the next step was to determine the sample size for each individual state. This was a

proportional allocation based on the FARS data for the state compared to the total for the six states to be sampled. Table 2.5 shows the six states selected and the number of fatal accidents occurring in each of the six states. The proportion of the individual state's accidents compared to the total is demonstrated under the "Percent of Sample" column. This percentage was multiplied by the total sample size to obtain the sample size for the individual states.

Table 2.5 Selected States and Sample Sizes

Stratum	State	Number of Fatal Accidents	Percent of Sample	Number Sampled For Two Years
1	Florida	574	41.6	1498
1	Ohio	383	27.7	1000
2	Missouri	229	16.6	598
2	Washington	114	8.3	296
3	Idaho	47	3.4	122
3	Delaware	33	2.4	86
Total		**1380**	**100**	**3600**

2.13 Sampling Procedure

The sampling was performed three different ways; on-site screening, on-site report collection, and state data collection. The three different methods were chosen based on time, finances, and cooperation of the selected state.

On-site screening required an OSU representative to travel to a state's central commercial vehicle accident records location. While at the site, the representative selected the records and screened them, photocopying only the records demonstrating a mechanical defect as a possible contributing factor to the accident. This procedure was used only in Missouri.

On-site collection occurred when an OSU representative selected and photocopied all of the sample data. The data was then analyzed at OSU. This procedure enabled research personnel to minimize the time spent at the state records office. Washington was sampled in this fashion.

The last method, state data collection, was performed for Florida, Ohio, Delaware and Idaho. In this case, a representative from the selected state sent OSU staff a list of all commercial vehicle accidents for the given years. The list included fields for type of vehicle, accident number, and if a mechanical defect, other, or unknown was listed as a contributing factor. Once at OSU, the sample reports were selected from the population using the process listed below. A copy of the selected accident reports was then requested to be sent to Oregon for further analysis.

In all cases, systematic sampling was used to select the records from the database. This procedure consisted of dividing the total number of commercial vehicle accidents by the sample size for that state. If the resultant number was five (truncated to the nearest integer), every fifth record was pulled. A random number determined which record to select first; 1, 2, 3, 4, or 5. For example, if the study required 100 records from a state that had a total of 400 accidents reported for the selected year, every 4th record would be collected. If the random number (between 1 and 4) used to begin this selection procedure was 3, then the researcher collected records 3, 7, 11, 15, ... until the sample size was reached.

3.0 COST INTEGRATION

This report utilized two methods to weigh the seriousness of mechanical defects. The first, and most obvious, involved the number (or proportion) of CMV accidents with a mechanical defect as a contributing factor. As a result, the defects associated with the most accidents were viewed as the problem areas. The second method involved the costs associated with the accidents observed in the sampling portion of this paper. In the latter case, the defects accruing the highest costs were viewed as the problem areas.

In order to assign a single value to each accident, the damages were translated into monetary figures. As the observed damages included deaths and injuries, the cost figure placed a monetary value on human life. This chapter establishes the rational used for the assignment of monetary costs for CMV accidents incurring property damage only, injuries, and fatalities.

3.1 Cost Analysis Methods

There are three primary methods developed to place a monetary value on human life [13, 6]. These methods: 1) human capitol, 2) years lost, and 3) comprehensive, assign a monetary value for human life that can be applied to accidents. Each method combines two types of costs, direct and indirect. The direct costs, covered in section 3.1.1, are the same for each approach. The methods to calculate indirect costs are briefed in sections 3.1.2 to 3.1.4.

3.1.1 Direct Costs

Direct costs are straightforward financial costs resulting from an accident. They include [13]:

personal health care for injured
property damages
crash clean-up
home modification requirements
workplace disruption
vocational rehabilitation
travel delays
insurance processing and legal fees

The direct costs do not include any value for the years of life that an accident victim may lose, the decrease in quality of life, earning potential lost, or pain and suffering.

Average direct costs vary depending on the type of accident. For example, motor vehicle accidents accrue more direct costs than skateboarding accidents due to higher property damages. The direct costs shown in this study represent those for motor vehicle accidents with special attention to medium and heavy trucks.

3.1.2 Human Capitol Approach

The human capitol approach is the oldest recorded method used to place monetary values on human life [13]. With the human capitol view, a person's value is his or her production of goods over time. The loss of an individual's production caused by an accident is the indirect cost of that accident. The cost of lost individual production falls into two categories. First, there are the wages that would have been earned had the accident not occurred. This is referred to as mortality cost. Second, is

the value that society places on the goods that the individual would have produced. This is designated as morbidity cost [13].

According to Rice, et al., direct costs accounted for 25% of the total cost for motor vehicle accidents. Mortality accounted for 39%, and morbidity 36% [13].

Researchers estimate the values for the human capitol method in two ways. The prevalence method occurs when the researchers limit their view to one year. For example, to consider 1991, all the costs for the accidents occurring in 1991 plus all costs occurring in 1991 for accidents that happened in prior years are accumulated. This is the most common method. The second estimation method, incidence, accounts for all of the costs related to all of the accidents occurring in a particular year. Expenses occurring in the years following an accident are charged to the year in which the accident took place [13].

There are some problems with the human capitol method. Women and minorities are under-valued, due to lower market values. Children and elderly are also under-valued, as a year of lost production has little value. Finally, if the labor market is poor, the individual working in that market is undervalued [13, 6].

3.1.3 Years Lost Approach

The years lost approach, often presented as years lost plus direct costs, presents two dissimilar types of data. This method estimates the amount of years of life lost due to injuries and fatalities and combines it with direct costs. The result is a number of life years and a dollar figure [13]. This may be acceptable when comparing two different safety project alternatives, but somehow, a cost must be

placed on the value of life. It is difficult to compare Alternative A with a cost of 34 life years and $70 million to Alternative B that has a cost of 45 life years and $52 million. While reviewing literature for this project, research found reference to the years lost approach, but no studies actually using it.

In order to calculate the number of years of life lost due to injury, data was taken from medical studies that compares the longevity of accident victims to the population [14]. Not surprisingly, more serious accidents result in more years subtracted from a victim's expected life.

3.1.4 Comprehensive Approach

The comprehensive method for placing a monetary figure on human life reflects the individual's valuation of health and life. It values life comprehensively by attempting to assess pain, suffering, and quality of life [13]. The method is sometimes referred to as the "willingness to pay" approach.

Comprehensive figures are based on three areas. First, there is the wage differential for risky jobs. The chance of death and injury combined with the increased wages are translated into a value for life. The second area is the price of safety improvements in goods. A reduction in the chances of injury or death is combined with the costs for the items that effect the decrease. Finally, tradeoffs between safety and time and money are considered. Thus, the comprehensive values are the amount that individuals place on life and wellness [15].

Automotive airbags provide an example of how this system works. Individuals purchase airbags for safety considerations. If the airbag reduces the risk

of death in an automobile accident by 1/10,000, then, statistically, 10,000 airbags will save 1 life. Suppose the consumers pay $250 for each airbag. Then 10,000 airbags at $250 each cost at total of $2,500,000. By this reasoning, the consumers, as a whole, spent $2,500,000 to save one life.

Non-fatal injuries are rated using the years of life lost technique described in section 3.1.3.

Major benefits over the human capitol and years lost methods for calculating a monetary value of life include:

1) Accountability for individuals' value for quality of life and pain and suffering.

2) Explanation of people's behavior. Not what people say they are willing to do, but the actual exchange of money, time, convenience, and comfort for safety.

3) It places a monetary value on life and injuries which allows for easy comparison between options.

The major detriment to the comprehensive method is the assumption that people act rationally when making decisions about health and safety.

Since 1986, virtually every federal regulatory agency that works with the monetary cost of life uses the comprehensive method [16]. In 1991, Miller, et al., recorded that the comprehensive method was the preferred method of assigning costs to accidents by the following sources [6]:

National Safety Administration, 1989
United States Office of Management and Budget, 1989
Federal Highway Administration, 1988
Gillette and Hopking, 1988
Menzel, 1986

Sixty-nine studies were identified that calculated the statistical value for life. Forty-nine were judged to be technically sound. The mean value for one life was $2.2 million with a standard deviation of $0.6 million and a range from $1.0 to $3.6 million [17, 6]. The values are listed in 1988 dollars.

3.2 Assigning Costs to Accident Reports

The task of assigning costs to accidents relied on information existing in the accident reports. Unfortunately, the only information available for cost purposes was an indication that the accident incurred fatalities, injuries, or property damage only. The assignment of a cost to these accidents relied on research primarily lead by Ted R. Miller. In the course of several papers, Miller calculated the average costs for accidents involving property damage only, injuries, or fatalities. The property damage only accidents were the least complicated, requiring a summation of the direct costs associated with the accident. The fatality accidents were fairly straightforward, relying heavily on the previously determined comprehensive value of life. Injury accidents, on the other hand, required much work, explanation, and documentation. Section 3.2.1 describes the basis for cost figures. Section 3.2.3 relates costs to the accident report options.

3.2.1 Cost Basis

The assignment of costs to automotive injuries relied on two databases; The National Accident Sampling System (NASS) and the National Council on

Compensation Insurance's Detailed Claim Information (DCI) [6]. An overview of the NASS sampling system appears in Appendix A.

The NASS database is a nationally representative sample of about 45 thousand injury victims. The injuries are coded with medical descriptors and Abbreviated Injury System (AIS) scores. The AIS was developed by the American Medical Association and the American Association for Automotive Medicine as a way to measure automotive accident severity. It is also known as the MAIS, where only the maximum, or most serious, injury is recorded. The AIS consists of the following categories:

0	Uninjured
1	Minor injury
2	Moderate Injury
3	Serious Injury
4	Severe Injury
5	Critical Injury
6	Maximum Injury (Instant Fatality)

The DCI database describes the medical payments and long term affects of workplace disruption based on the coding given by NASS. In order to calculate an average cost per AIS injury, the type of injury and the incident percentages from NASS were assigned a cost using the DCI [6].

Unfortunately, a different coding system exists on the accident reports, designated KABCO. This was developed for police coding at the accident scene. Unlike the MAIS system, it does not require medical judgment. The KABCO system contains the following categories:

K Killed
A Incapacitating Injury
B Evident Injury
C Possible Injury
O Property Damage Only

There are several problems with the KABCO system. First, the police are supposed to follow up on all of the injuries. If any accident causes an injury that resulted in a fatality within 30 days, regardless of initial classification, the accident report should be changed to represent the fatality. In reality, the condition of many accident victims is not checked in 30 days. In addition, most officers record injuries more severely for women, bloody injuries rate more severe, and officers with less crash experience rate injuries more severe. The system also does not rate the damage to the victim particularly well. For example, a severed spinal cord rates an A, the same as a broken leg [6].

To simplify the report for the individual filling it out, the KABCO system is frequently compressed into three categories, Killed, Injured, or Property Damage Only. In this format, the incapacitating, evident, and possible injuries are absorbed into the injured category. This is the method used by the National Highway Traffic Safety Administration in their yearly publications titled Traffic Safety Facts [3].

Regardless of the drawbacks, the KABCO system is dominant on the accident reports and was the only system encountered while analyzing accident reports for this project.

In a step of primary importance to this report, KABCO ratings were matched to MAIS ratings [6]. This allowed a cost assignment to the KABCO ratings found in accident reports.

3.2.2 Cost Assignment

This report uses the average cost per crash figures published by Miller, et al. The average automotive accident resulting in a fatality costs $2,829,750. Injury accidents, a summation of categories A, B, and C in the KABCO system, cost an average of $69,592. An average property damage only accident costs $4,146 [13]. The figures were given in 1988 dollars.

For commercial vehicle accidents, the direct costs increased by $7,189 (in 1988 dollars) [6]. As a result, this report utilized the following costs per accident (in 1988 dollars):

Fatality	$2,836,939
Injury (A, B, C)	$76,781
PDO	$11,335

3.3 Adjustment to 1994 Dollars

To present this report in the most current manner, the above figures were adjusted to account for inflation. This adjustment was based on the consumer price index (CPI). The report utilizes the CPI for urban consumers as the costs involved items ranging from an individual's production value to medical costs to towing fees. This format was recommended by T. R. Miller in The Costs of Highway Crashes [6],

and used in the National Highway Traffic Safety Administration's 1992 publication The Economic Cost of Motor Vehicle Crashes, 1990 [18].

From the CPI Detailed Report published by the US Bureau of Labor Statistics, the CPI number for 1988 is 118.3 [19]. The CPI number for 1994 is 148.2 [20]. These two numbers result in a ratio of 1.2527. The cost per accident figures were multiplied by the resultant ratio. Table 3.1 lists the resulting accident costs that were used when assigning costs to accidents observed in the OSU sample.

Table 3.1 Accident Costs

Accident type	1988 dollars	1994 dollars
Fatality	$2,836,939	$3,553,939
Injury (A, B, C)	$76,781	$96,187
Property Damage Only	$11,335	$14,200

Note that these figures are averages per accident. Therefore, the same cost values would be applied to an accident causing 1 fatality as an accident that resulted in 8 fatalities.

4.0 ADDITIONAL SOURCES

In addition to the accident reports collected under the sampling plan described in Chapter 2, information was taken from two other areas. The first area includes information compiled at the national level, or national databases. The second area consisted of accident inspection reports. A summary of the inspection reports for each source appears in Appendix F. Appendix G contains the combined results for the additional sources. These additional sources of information were evaluated for comparison with the present study.

4.1 National Databases

National databases are a very prominent source of information. In fact, most studies regarding vehicle accidents and their associated costs rely heavily on information gathered from national databases. Conveniently, as the data is already assimilated, it is much easier to evaluate than individual accident reports.

Two national sources were analyzed for information regarding CMV accidents and mechanical defects. The General Estimates System (GES) database for 1993 and 1994 was chosen for three reasons. First, it is very well known. Second, the findings are representative of the entire population of CMV accidents, not a subset. Third, the database is current. The Motor Carrier Safety (MCS) database for 1976 through 1978 kept by the United States Department of Transportation Federal Highway Administration (USDOT/FHWA) was also selected. Despite the age of the data, the

MCS database was evaluated because it provided detailed information about vehicle defects.

While these databases contain information about drivers, vehicles, roads, injuries, etc., this report only considered those which indicated a mechanical defect. With each database, there was no assurance that the defect contributed to the accident.

4.1.1 1993-1994 General Estimates System

OSU contracted with the University of Michigan Transportation Research Institute (UMTRI) to examine existing national databases covering vehicle accidents. UMTRI was chosen due to its expertise with these databases. The GES information utilized in this report was prepared by Massie, et al. [21], at UMTRI.

The GES produces national estimates based on a complex sampling system of police reported accidents (see Appendix A). Information about occurrences and proportions per defect category as provided by UMTRI can be found in Appendix G.

The results indicated that 2.67% of the CMVs involved in accidents had a mechanical defect. Twelve defect categories were listed, along with a category for "other defects" and a category for "unknown defects." There was no breakdown for the categories. For example, the GES suggested that faulty brake systems were indicated in almost 0.75% of the population for CMV accidents. It did not give any information about the nature of the brake defect. A comparison of the proportional estimates for the broad categories between the OSU study, national databases, and investigation data appears in Section 6.

4.1.2 Motor Carrier Safety 1976 - 1978

All accidents involving a federally regulated motor carrier and a fatality, injury, or property damage of $2,000 or more should have been reported to this database. The information, recorded by the individual carriers on 50-T forms, was very detailed. The database provided the most specific classifications of defects found in national databases. A major drawback of the MCS database was underreporting. It is estimated that motor carriers submitted reports for less than 50% of the qualifying accidents [22, 23]. Unfortunately, the database was discontinued in 1992.

The results indicated that 4.9% of the CMVs involved in accidents had a mechanical defect. Eighteen defect categories were listed. These categories were broken into over 100 specific sub-categories. For example, the MCS suggested that faulty brake systems were indicated in 1.5% of the population for CMV accidents. In contrast to the GES system, the break system category was broken into 18 sub-categories. The MCS database indicated that while 60% of the brake defects were unspecified, 9.2% of the brake defects were attributed to the parking brake, 7.7% were attributed to brake lines, and 6.3% were attributed to springs, cams, and adjusters. A comparison between the OSU study, national databases, and the investigation database for this report appears in Section 6.

4.2 Accident Inspection Data

Accident inspection data varied drastically from both the state data collected for this study and national data. First, inspections were performed on a small

proportion of police reported accidents. This study evaluated approximately 450 inspections performed by five government agencies. The time period ranged from one to three years (between 1993 and 1995), depending on the availability of the data.

Second, research for this study failed to observe inter-jurisdictional standards for establishing which accidents were evaluated. Each agency has its own criteria, based on property damage, injury severity, location, and inspector availability. As an additional source of variation, the inspection was frequently initiated by a request from the officer at the accident scene if the officer decided the accident warranted an inspection. While the threshold requirements for PARs used in state and national databases varied, it was much more consistent across states than the inspection reporting requirements.

The third difference was the objective of the reports. The inspection reports tried to establish what happened. The inspectors gave full attention to analyzing the actions of the drivers, vehicle responses, as well as inspecting the vehicle. The inspector was not concerned with treating injuries or clearing the roadway for public traffic. As a result, much more information about the condition of the vehicle was compiled in the inspection reports than the state and national databases.

A major drawback concerning the inspection reports was the lack of uniformity. The requirements for performing an inspection were inconsistent, resulting in an undefined population. Therefore, the gathered information could not be used to draw inferences about the entire population of commercial vehicle accidents. Thus, findings were limited to observations about the observed accidents.

The five sets of accident inspection reports analyzed for this study were provided by the following governmental agencies:

National Transportation Safety Board
Kansas City, Missouri Police Department
Maryland Commercial Vehicle Enforcement Division
Maine State Police
Colorado State Patrol

Appendix F contains a summary of the data collected from each of these sources.

4.2.1 National Transportation Safety Board Study

The National Transportation Safety Board (NTSB) conducts a relatively small number of thorough accident investigations. The investigations cover motor carriers, shippers, governmental and other interested agencies. As a result of the in-depth coverage and longer investigation time frames, the NTSB reports provide a better estimate of long term crash effects than the aforementioned sources of information [23]. The NTSB investigation results, similar to the other accident investigations, may not represent the national population of commercial vehicle accidents.

This report evaluated a NTSB special study of 189 CMV accidents involving a CMV of over 10,000 pounds requiring towing assistance as a result of the accident. Thirty-three were judged defect related and entered into the inspection database for this report. A comparison of the OSU study, national databases, and the investigation database appears in Chapter 6.

4.2.2 Kansas City, Missouri Police Inspection Reports

The Kansas City, Missouri Police Department performed 129 inspections in a one year period from October 1994 to September 1995. Research for this report obtained a copy of all 129 inspection reports. Eighteen were found to be defect related and entered into the inspection database.

4.2.3 Maryland Commercial Vehicle Enforcement Inspection Reports

The Maryland Commercial Vehicle Enforcement Division conducts approximately 125 inspections per year. Maryland personnel selected 28 inspection reports from the years 1994 and 1995. Twenty-three of these reports were entered into the inspection database.

4.2.4 Maine State Police Inspection Reports

Representatives from Maine submitted 10 accident inspection reports for this report. Five of these were entered into the inspection database.

4.2.5 Colorado State Patrol Inspection Reports

The Colorado State Patrol performs approximately 125 accident inspections per year. Thirty-seven of these reports were submitted for this report. Twenty of the reports were entered into the inspection database.

5.0 SAMPLING STUDY RESULTS

5.1 Sample Data Accumulation

OSU researchers gathered sample data in accordance with the plan described in Chapter 2. The information was then assimilated in spreadsheet form. Nineteen categories were used to group the accidents based on defect type. Appendix B contains the information taken from the accident reports as compiled in spreadsheets.

Some discrepancies occurred with the actual sample sizes and the target, or ideal, sample sizes. Table 5.1 shows that the OSU team slightly over-sampled.

Table 5.1 Target Verses Actual Sample Sizes

Stratum	State	Target Sample Size ('93 + '94)	Actual Sample Size ('93 + '94)
1	Florida	1498	1500
1	Ohio	1000	1011
2	Missouri	598	754
2	Washington	296	395
3	Idaho	123	142
3	Delaware	86	86
Total		**3601**	**3888**

5.2 Results by State

The sample accident data for each state was tabulated according to defect category. Calculations were performed to estimate two measures for each category; sample proportion and confidence limits. The estimated sample proportion is the number of accidents with a specific mechanical defect as a contributing factor divided by the sample size. For example, if State Z recorded 5 accidents with brakes as a

contributing factor, and had a sample size of 500, the resultant estimated proportion for brake defects was 1%. The estimated proportion for a certain defect category found in state j in stratum h is designated $\hat{P}_{hj}$.

The confidence limits relied on the binomial and F-distributions [10], as described in Sections 2.8 and 2.9. At the state level, n represents the sample size for the state and X represents observed occurrences for a specific defect in the state. A 90% confidence interval for $\hat{P}_{hj}$ was used.

$$\text{Upper confidence limit} = \frac{(X+1)\times F_{(1-.90)/2,2(X+1),2(n-X)}}{(n-X)+(X+1)\times F_{(1-.90)/2,2(X+1),2(n-X)}}$$

$$\text{Lower confidence limit} = \frac{X}{X+(n-X+1)\times F_{(1-.90)/2,2(n-X+1),2(X)}}$$

Appendix C contains the proportions and variances of proportions for the individual states.

5.3 Results by Stratum

Stratum calculations were estimated for the same two measures (proportions and confidence limits). The estimated proportion for each stratum, $\hat{P}_h$, was calculated by summing the proportions of each sampled state in the stratum and dividing by the number of states. The equation is [24]: $\hat{P}_h = (1/x_j)\times\sum_{j=1}^{xj}\hat{P}_{hj}$, where x_j is the number of states in stratum h.

The confidence limits for the strata relied on the same equations as the state confidence limits, with n equaling the sample size for the strata and X representing the observed occurrences in the strata.

Appendix D contains the proportions and variances of proportions for the three strata.

5.4 Results for the United States

5.4.1 National Proportions

The two measures were estimated at the national level. The proportional estimate was calculated by the following formula [25]: $\hat{P} = (1/N) \times \sum_{h=1}^{xh} N_h \times \hat{P}_h$, where xh is the number of strata, N_h is accident population for stratum h, and N is the population for the United States (sum of stratum populations).

Surprisingly, the CMV accident populations for each state were unobtainable. Contact was made with state personnel in all 50 states in an effort to obtain the CMV accident populations. State accident population data presented three primary problems. First, several states were unable to sort their accident database by vehicle type. They had no idea how many CMV accidents were reported. Some of the states could gather information on one year, but not both. Second, the conditions necessary for an accident to be specified as a CMV accident varied. Third, some of the numbers were not believable (see New York State numbers in Table 5.2).

Table 5.2 lists the CMV accident populations submitted for this study from the individual states. Also included is the number of CMV fatal accidents, as recorded in the FARS database. Appendix H gives a brief description of the CMV accident population database for each state.

As a result of the inconsistencies, the report based the national proportional estimates on FARS data, instead of the state accident population data. The national proportion formula was altered to use the FARS data. First, the national population of fatal CMV accidents was substituted into the equation for the total national population of CMV accidents. Second, the stratum population of fatal CMV accidents was substituted into the equation for the stratum population of all CMV accidents. As a result, the strata were weighted according to the reliable FARS data.

Letting F_h equal the number of fatal accidents occurring in stratum h, and F_{total} equal to the total number of fatal accidents, the national proportion equation becomes:

$$\hat{P} = (1 / F_{total}) \times \sum_{h=1}^{xh} F_h \times \hat{P}_h .$$

Table 5.3 compares the relative weight of each stratum based on state reported accident populations to the relative weight of each stratum based on FARS data.

It appears that the GES also failed to obtain acceptable accident population data. They used the number of fatal and injury accidents with a probability proportional to size (PPS) method to select sampling units. See Appendix A.

Table 5.2 **Comparison of State Reported Accident Populations to Fatal Accidents**

Strata	State	93 Population	94 Population	'93 + '94 Pop.	'93 + '94 FARS
1	California	31,897	33,791	65,688	694
1	Texas	19,923	21,714	41,637	679
1	Florida	11505	11787	23,292	574
1	Pennsylvania	6102	8252	14,354	395
1	Ohio	16,198	15,685	31,883	383
1	North Carolina	7,959	8,805	16,764	382
1	Georgia	21,333	15,386	36,719	353
1	New York	725	762	1,487	330
1	Illinois	15869	15394	31,263	321
1	Alabama	9,636	10,664	20,300	300
1	Michigan	19,139	16,152	35,291	287
1	Indiana	21,766	26,381	48,147	274
1	Tennessee	N/A	N/A	0	259
2	Missouri	10,953	10,819	21,772	229
2	Virginia	9086	10434	19,520	216
2	Kentucky	10,366	9,446	19,812	194
2	Wisconsin	9028	9935	18,963	193
2	Louisiana	6758	5830	12,588	192
2	Arkansas	4,057	4,471	8,528	187
2	South Carolina	10997	12202	23,199	179
2	Mississippi	6,217	6,708	12,925	166
2	Iowa	4565	N/A	4,565	159
2	Oklahoma	3393	3458	6,851	155
2	Arizona	5099	5296	10,395	147
2	New Jersey	9991	N/A	9,991	143
2	Minnesota	4931	5312	10,243	138
2	Oregon	2,601	2,327	4,928	125
2	Maryland	11693	11680	23,373	121
2	Kansas	2,501	2,309	4,810	116
2	Washington	6,029	6,590	12,619	114
2	Colorado	N/A	N/A	0	111
2	Nebraska	N/A	1295	1,295	101
2	West Virginia	4165	3908	8,073	98
2	Massachusetts	N/A	N/A	0	75
2	New Mexico	1808	1825	3,633	72
3	Nevada	N/A	226	226	53
3	Utah	1759	1750	3,509	53
3	Connecticut	4873	5501	10,374	52
3	Idaho	1,599	1,387	2,986	47
3	Maine	2340	2371	4,711	41
3	Delaware	1,150	1,063	2,213	33
3	South Dakota	120	138	258	32
3	Wyoming	1510	1216	2,726	32
3	Montana	1,041	738	1,779	29
3	North Dakota	799	774	1,573	26
3	Vermont	523	476	999	23
3	New Hampshire	367	413	780	16
3	Rhode Island	N/A	N/A	0	14
3	Hawaii			0	10
3	Alaska			0	8
	TOTAL	32,2371	31,4671	63,7042	8,931

Source: Traffic Safety Facts 1993, Large Trucks, Traffic Safety Facts 1994, Large Trucks, and state personnel from all 50 states.

Table 5.3 Stratum Relative Weight Comparison

Stratum	Recorded Population (two years)	Recorded Population Relative Weight	Fatal Accidents	Fatal Accidents Relative Weight
1	366,825	0.5758	5,231	0.5857
2	238,083	0.3737	3,231	0.3618
3	32,134	0.0504	469	0.0525
Total	**637,042**	**1.0000**	**8,931**	**1.0000**

In summary, this report accepted the GES estimate for total number of police reported CMV accidents per year. The stratum proportions were then weighted based on the proportion of fatal accidents occurring in each stratum.

This weighted average, where the strata with a higher number of accidents carry a representative amount of the proportion, coincides with the strategy used for the stratification process. The states within each stratum did not use weighted averages as the strata were divided to contain states of similar accident population sizes.

Again, confidence limits utilized the same equations. This time, n was equal to the entire sample size, and X equaled the number of observed occurrences in the sample.

Appendix E contains the estimated proportions and 90% confidence limits for the proportions for the United States.

5.4.2 Defect Categories Ranked by Estimated Proportion

Table 5.4 presents the proportion results of the sampling portion of this study. The first column represents the defect category. The second column is the estimated

proportion of all CMV accidents with the defect category from that row as a contributing factor. The third column represents the specific sub-items for the category. The fourth column signifies the percent of the category that was attributed to the specific sub-item. An "*" indicates items represented in the OOS criteria.

As the defect proportions attributed to the specific sub-items were often spread over many items, this table attempts to cover the majority for each broad category. Therefore, a summation of the percent of category column for each of the broad categories will not add to 100%. The occurrences of all defect categories along with specific sub-items found in the OSU sampling study are located in Appendix B.

Table 5.4 Defects Ranked by Estimated Proportion

Defect Category	Estimated Portion of All CMV Accidents	Specific Defect	Percent of Category
Brakes	1.665%	Other or unknown	80.0%
		Parking brake *	9.2%
		lines *	4.6%
		Wheel cylinder	4.6%
Tires	0.446%	Blowout	77.8%
		Tread, worn *	11.1%
Other or Unknown	0.397%		100.0%
Coupling	0.382%	Other or unknown	86.7%
		Locking and Release mechanism *	0.0%
		Fifth wheel kingpin *	0.0%
		Fifth wheel *	0.0%
Load Securement	0.369%	Part of load fell out *	57.1%
		Tie downs, chains, etc. *	21.4%
		Other or Unknown	21.4%
Wheels	0.329%	Other of Unknown *	92.2%
		Wheel bearings	7.7%

Table 5.4 Defects Ranked by Estimated Proportion (continued)

Defect Category	Estimated Portion of All CMV Accidents	Specific Defect	Percent of Category
Body	0.201%	Other or unknown	42.9%
		Cargo doors, trailer body panels, floor, etc.	28.6%
		Spare tire rack *	14.3%
		Trailer support (landing gear)	0.0%
Electrical	0.194%	Lights, tail *	33.3%
		Lights, turn and hazard *	22.2%
		Lights, head *	0.0%
		Lights, other	0.0%
Driveline	0.176%	Fell out (part or all)	85.7%
		Shaft broke	14.3%
		Other or unknown	0.0%
Steering	0.109%	Tie rod (loose)*	50.0%
		Other or unknown	25.0%
		power steering system *	0.0%
Suspension	0.092%	Other or unknown	50.0%
		Spring *	50.0%
		Shackle, pin, hanger *	0.0%
Fuel System	0.070%	Throttle linkage	100.0%
		Fuel lines, valves *	0.0%
		Other or unknown	0.0%
Frame	0.065%	Rails and reinforcement *	100.0%
		Other or Unknown	0.0%
Axle	0.055%	Axle shaft broken	50.0%
		Fell off	50.0%
		Adjustable *	0.0%
Engine	0.044%	Other or Unknown	100.0%
		Oil pump, lube system	0.0%
Transmission	0.039%	Other or Unknown	100.0%
		Clutch linkage	0.0%
		Shift controls & linkage	0.0%
Accessories	0.000%	Other or unknown	0.0%
		Speedometer	0.0%
		Windshield wiper contrl *	0.0%
Cooling system	0.000%	Hoses, clamps, cap, thermostat, shutters	0.0%
Exhaust	0.000%	Exhaust pipe, hangers	0.0%
		Other or Unknown *	0.0%
Totals	4.633%		

* indicates representation in the CVSA OOS criteria.

5.4.3 National Occurrences

Using the estimated proportions for each defect category, this study estimated the number of accidents to which the defect contributed over a one year period. In addition, confidence intervals for these numbers were calculated. The estimated number of accidents for each category, designated *t*, is found by the following equation: $t = N \times \hat{P}$. The equation simply describes the number of national occurrences for each category, *t*, as the product of the total number of CMV accidents in one year, *N*, multiplied by proportion of accidents with the defect as a contributing factor, $\hat{P}$.

The low and high limits for the number of accidents with a contributing factor (by defect category) were calculated in accordance with a 90% confidence level. Thus, the estimated value of *t* will be within the low and high limits in 9 out of 10 identical studies. The following formulas were used to calculate the low and high limits for *t*, the number of accidents with a mechanical defect as a contributing factor occurring in one year: $t(low) = N \times \hat{P}(lower)$ and $t(high) = N \times \hat{P}(upper)$.

In the above equation, *t(low)* represents the lower confidence limit for *t*, and *t(high)* represents the upper confidence limit for *t*. $\hat{P}(lower)$ represents the lower confidence limit for the proportion of all CMV accidents with a certain defect as a contributing factor. Likewise, $\hat{P}(upper)$ represents the upper confidence limit for the proportion of all CMV accidents with a certain defect as a contributing factor.

Equations establishing $\hat{P}(lower)$ and $\hat{P}(upper)$ were given in Section 2.9 and Section 5.2.

Appendix E contains the single year estimated numbers along with low and high limits for CMV accidents with a mechanical defect as a contributing factor in the United States.

5.4.4 Defect Categories Ranked by Estimated Occurrences

Table 5.5 presents the estimated occurrence results of the sampling portion of this study. The results are for one year and based on an accident population of 400,000.

Table 5.5 Defects Categories Ranked by Estimated Occurrences

Defect	*t* (Occurrence Estimate)	Upper Confidence Limit	Lower Confidence Limit
Brakes	6,659	8,205	5,392
Tires	1,785	2,743	1,198
Other or Unknown	1,589	2,621	1,115
Coupling	1,527	2,374	952
Load Securement	1,476	2,249	871
Wheels	1,316	2,124	792
Body	803	1,352	338
Electrical	776	1,614	483
Driveline	704	1,352	338
Steering	436	941	141
Suspension	366	647	37
Fuel System	279	647	37
Frame	261	647	37
Axle	218	647	37
Engine	174	647	37
Transmission	156	647	37
Accessories	0	308	0
Cooling System	0	308	0
Exhaust	0	308	0
Total Estimated	**18,527**	**20,999**	**16,449**

Note that the confidence limits for the total estimated occurrences are the confidence limits for 18,527, and not the sum of the confidence limit columns.

5.5 Results Based on Cost Observed in Sample

Table 5.6 ranks the aforementioned broad defect categories in order of cost for the evaluated PARs. With little information concerning cost variances, the report could not extend cost factors to the national level with statistical validity. Therefore, the ranking is based on the observed data.

Table 5.6 Defect Categories Ranked by Estimated Cost

Defect Category	Total Cost Observed in Sample
Other or Unknown	$7,894,787
Load Securement	$3,984,500
Transmission	$3,650,126
Brakes	$3,628,571
Tires	$911,496
Electrical	$701,709
Coupling	$540,948
Wheels	$348,574
Body	$263,374
Driveline	$263,374
Steering	$138,787
Frame	$110,387
Fuel System	$110,387
Suspension	$110,387
Axle	$28,400
Engine	$28,400
Accessories	$0
Cooling System	$0
Exhaust	$0
Total	**$22,714,207**

Note that the rankings are extremely sensitive to fatality costs. For example, the Load Securement category included costs for one fatality. If that fatality had been an injury, Load Securement would be ranked seventh on the list, instead of second. Due to the extreme weight of fatality accidents, the report was unable to draw strong conclusions from the cost data.

6.0 ANALYSIS

In the effort to examine OOS criteria, this report focused on mechanical defects that contributed to accidents. Research for this project included a sample of over 3,800 accident reports, evaluation of national databases, and evaluation of investigation report databases. Section 6.1 makes some comparisons between the sources of information.

6.1 Data Comparisons

Results from the sampling portion of this report matched the detailed MCS database within 0.25% (0.0025) for the total proportion of CMV accidents with a mechanical defect as a contributing factor. The GES database recorded roughly half of that proportion.

The accident investigation data could not be included in this comparison as the sample was not indicative of the population. Each investigation agency has its own criteria for selecting the accidents to be investigated, based on accident severity, available work force, type of cargo, and other factors. For this reason, no information from the accident investigation database could be used to draw inferences about the CMV accident population.

Table 6.1 presents a comparison of the OSU sample results, the GES results, and the MCS results.

Table 6.1 Database Comparison by Proportion

Database	OSU Sample 1993-1994	GES 1993-1994	USDOT MCS 1976-1978
Defect Category	Estimated Proportion of All CMV Accidents	Estimated Proportion of All CMV Accidents	Proportion of Sample
Brakes	1.665%	0.749%	1.471%
Tires	0.446%	0.676%	1.542%
Other or Unknown	0.397%	0.797%	0.000%
Coupling	0.382%	0.122%	0.228%
Load Securement	0.369%	0.000%	0.017%
Wheels	0.329%	0.062%	0.266%
Body	0.201%	0.000%	0.105%
Electrical	0.194%	0.141%	0.158%
Driveline	0.176%	0.036%	0.031%
Steering	0.109%	0.052%	0.300%
Suspension	0.092%	0.033%	0.199%
Fuel System	0.070%	0.000%	0.147%
Frame	0.065%	0.000%	0.039%
Axle	0.055%	0.000%	0.099%
Engine	0.044%	0.000%	0.145%
Transmission	0.039%	0.000%	0.066%
Accessories	0.000%	0.002%	0.031%
Cooling system	0.000%	0.000%	0.017%
Exhaust	0.000%	0.000%	0.006%
Totals	**4.633%**	**2.670%**	**4.867%**

From Table 6.1, it is observed that the categories of Brakes, Tires, Couplings, Load Securement, and Wheels account for 68.9% of the OSU sample, 60.3% of the GES sample, and 72.4% of the MCS database.

An interesting aspect of the table is the 0% recorded for the Other or Unknown category for the MCS database. One theory attributes the low value to the method of data collection. It seems unlikely that a motor carrier, when filling out an accident report for one of its trucks, would indicate that a defect contributed to the accident, while having no idea about the nature of the defect.

The high values of Other or Unknown in the other two databases are result of incomplete information. The officer filing the accident report must have known the nature of the indicated mechanical defect, or the officer would not have indicated a defect. Information about the nature of the defect was not transferred to check-boxes or the narrative section. The other or unknown category accounts for those accident reports that have a mechanical defect indicated, but no further information about the nature of the defect.

Comparison of the three databases strengthens the claim that the listed proportions are fairly accurate. Three different types of studies were analyzed; sampling of actual PARs (with emphasis on the narrative), sampling of PAR databases (with emphasis on check-box information), and detailed reports filed by motor carriers. The proportion of defects listed increased with the amount of detail in the database.

The proportion of mechanical defects as a contributing factor per defect category was fairly consistent between databases. The categories that incurred a high proportion of accidents in one database, also incurred a high proportion of accidents in the other databases. The tire category recorded the highest differential between the OSU sample and the MCS database (1%).

The following table, Table 6.2, presents a comparison of the specific sub-items in each defect category for four sources of information; the OSU sample, the GES estimate, the MCS database, and the accident investigation database compiled for this report. The percent of category that each sub-item incurred was not consistent

between sources. The most obvious feature was the lack of detail from the GES results.

As the defect proportions attributed to the specific sub-items were often spread over many items, this table attempts to cover the majority for each broad category. Therefore, a summation of the percent of category column for each of the broad categories will not add to 100%. The occurrences of all defect categories along with specific sub-items found in the OSU sampling study are located in Appendix B. The occurrences of all defect categories along with specific sub-items found in the other databases are located in Appendix G.

Table 6.2 Comparison of Specific Sub-Items

Database		OSU Sample	GES	USDOT MCS	Accident Inspection
Defect Category	**Specific Sub-Item**	**Percent of Category**	**Percent of Category**	**Percent of Category**	**Percent of Category**
Brakes	Other or unknown	80.0%	100.0%	59.6%	11.2%
	Parking brake *	9.2%		9.2%	0.9%
	Adjustment *				49.5%
	Lines *	4.6%		7.7%	6.4%
	Wheel cylinder	4.6%		0.8%	
Tires	Blowout	77.8%		51.5%	16.7%
	Other or unknown		100.0%	20.6%	
	Tread, worn *	11.1%			16.7%
Other or Unknown		100.0%	100.0%		
Coupling	Other or unknown	86.7%	100.0%	16.2%	16.7%
	Locking and Release mechanism *			21.1%	16.7%
	Fifth wheel kingpin *			15.7%	16.7%
	Fifth wheel *			27.9%	
Load Securement	Part of load fell out *	57.1%			
	Tie downs, chains, etc. *	21.4%			
	Other or Unknown	21.4%			25.0%
Wheels	Other of Unknown *	92.2%	100.0%	61.8%	
	Wheel bearings	7.7%		15.1%	

Table 6.2 Comparison of Specific Sub-Items (continued)

Database		OSU Sample	GES	USDOT MCS	Inspection
Body	Other or unknown	42.9%		4.3%	
	Cargo doors, trailer body panels, floor, etc.	28.6%		14.9%	
	Spare tire rack *	14.3%		24.5%	33.3%
	Trailer support (landing gear)			21.3%	
Electrical	Lights, tail *	33.3%			75.0%
	Lights, turn and hazard *	22.2%	81.6%	9.7%	
	Lights, head *		9.4%	52.8%	
	Lights, other		9.0%	36.1%	
Driveline	Fell out (part or all)	85.7%			
	Shaft broke	14.3%		60.7%	100.0%
	Other or unknown		100.0%	21.4%	
Steering	Tie rod (loose)*	50.0%		0.0%	20.0%
	Other or unknown	25.0%	100.0%	43.5%	
	power steering system *			23.8%	
Suspension	Other or unknown	50.0%	100.0%	21.4%	
	Spring *	50.0%		3.9%	50.0%
	Shackle, pin, hanger *			34.3%	
Fuel System	Throttle linkage	100.0%		28.8%	100.0%
	Fuel lines, valves *			22.7%	
	Other or unknown			31.8%	
Frame	Rails and reinforcement *	100.0%		62.9%	33.3%
	Other or Unknown			28.6%	
Axle	Axle shaft broken	50.0%		20.2%	
	Fell off	50.0%			
	Adjustable *			61.8%	
Engine	Other or Unknown	100.0%		77.7%	
	Oil pump, lube system			12.3%	
Transmission	Other or Unknown	100.0%		27.1%	
	Clutch linkage			20.3%	
	Shift controls & linkage			32.2%	
Accessories	Other or unknown			35.7%	
	Speedometer			21.4%	
	Windshield wiper contrl *		100.0%	25.0%	
Cooling system	Hoses, clamps, cap, thermostat, shutters			33.3%	
Exhaust	Exhaust pipe, hangers			20.0%	
	Other or Unknown *			80.0%	

* indicates representation in the CVSA OOS criteria.

Another interesting feature about the sub-item comparison is that the OSU sample and the MCS database are fairly close, while the accident inspection database is much different. This is exemplified by the adjustment row under the brake category. The OSU sample and the MCS database do not show any indication of brake adjustment as a problem. The accident investigation database, however, indicates that brake adjustment deficiencies were present in 50% of the investigated accidents.

Discussion among industry experts, as noted in the CVSA minutes, indicates that brake adjustment is a problem area [1]. In this case, for the importance within a category, it appears that the investigation database is more representative of the real world.

A plausible explanation exists for this discrepancy. Brake adjustment deficiencies are not easily detected by people other than trained inspectors. As a result, the brake defect is recorded as unknown. This may also explain the high percentage in the "unknown or other" row for the OSU and MCS databases.

6.2 Data Source Analysis

The four data types utilized for this study (OSU sample, MCS database, GES estimates, and accident investigation reports) can be grouped into three categories.

The OSU sample and the MCS have some common features. Both use the most detailed information available, without the use of an inspector. The OSU sample procedure analyzed the narrative section of police accident reports. These narratives contained detailed officer and accident participant statements. The MCS

database relied on information supplied by the participants via a comprehensive 50-T form. The results of the two studies were similar. This data collection approach is referred to as the narrative approach.

The GES stands alone as a national database relying on check-box information provided by police accident reports.

The third group, the accident investigation database, is the only source providing a qualified inspector's view of the vehicle condition.

The three information groups provided vastly different information. The narrative approach provided a means to find the proportion of CMV accident with a mechanical defect as a contributing factor. The narrative approach also provides a break down of this proportion into broad defect categories. The ability of the narrative approach to divide the broad categories into specific sub-items was limited.

The national check-box approach provided little insight. First, it could not decipher the difference between a mechanical defect noted on the accident report that did not contribute to the accident from a mechanical defect that actually contributed to the accident. Second, there was absolutely no breakdown of the broad defect categories into specific sub-items.

The third approach, accident investigation reports, could not produce any relationships to the CMV accident population. However, it provided the best information about the exact nature of a defect. Therefore, the accident investigation reports could be useful in determining the occurrences of specific defects, given a defect in a broad category.

6.3 Relationship of Accident Data and OOS Criteria

Analysis of the presented information indicates that the CVSA OOS criteria represents the categories incurring the highest proportion of mechanical defect related accidents. Table 5.4 and Table 6.2 show the top categories (in terms of accidents with a mechanical defect as a contributing factor) are all represented in the OOS criteria.

In addition, categories which are not heavily represented by accident data are not as heavily represented in the OOS criteria. The exception to this is criteria for the exhaust and criteria for the windshield wipers. These items were linked to very few accidents, yet were represented in the OOS criteria.

The driveline category lacks representation in the OOS criteria. Drivelines accounted for more accidents in the OSU sample and the GES sample than steering, frame, suspension, and fuel categories. However, drivelines accounted for less than these categories in the MCS database. As a result, the evidence supporting driveline inclusion in OOS criteria is not conclusive.

Throttle linkages are not represented in the OOS criteria, although the category that it belongs to, fuel systems, is represented in the OOS criteria. The OSU sample, the MCS database, and the accident investigation reports all relate the throttle linkage to more accidents than any other part of the fuel system.

Comparison of the OSU sample results with the MCS database leads to an interesting point. The OSU sample data was collected a dozen years after CVSA inception. Results from the OSU study estimate 4.6% of CMV accidents have a mechanical defect as a contributing factor. The MCS data was collected 3 to 5 years

before CVSA inception. Results from the MCS database show that 4.9% of CMV accidents indicated a mechanical defect. Although the results are similar, it is difficult to assess the effectiveness of the CVSA OOS criteria at reducing the proportion of mechanical defect related CMV accidents, due to data collection differences. One major difference was the OSU sample relied on police accident reports, while the MCS database utilized a voluntary disclosure of accident information.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Three general conclusions are drawn in this report. First, this study estimates the proportion of CMV accidents with a mechanical defect as a contributing factor at 4.6%. Three additional sources of information were utilized; General Estimate System estimates, USDOT Motor Carrier Safety data, and accident investigation report data. These additional databases do not contradict the OSU sampling result.

Second, the broad defect categories for brakes, tires, couplings, load securement, and wheels account the majority of defect related accidents (68.9% of the OSU sample, 60.3% of the GES sample, and 72.4% of the MCS database). In financial terms, transmissions, loading and securement, and brakes incurred the most damage.

The third conclusion is that while police accident reports (with an emphasis on the narrative sections) are sufficient to group the defects into broad categories, they are not sufficient to estimate proportions for specific defects. The data supplied by national databases relying on check-box information, and not narrative information, was of little use. The accident investigation reports provided the only detailed information of specific mechanical defects. However, no inference about the population of CMV accidents could be drawn from the accident investigation reports.

Table 7.1 groups the broad defect categories based on their contributions to CMV accidents.

Table 7.1 Accident Data Support For Defect Categories

Defect	Proportion Estimate	Support Level
Brakes	1.665%	High
Tires	0.446%	High
Coupling	0.382%	High
Load Securement	0.369%	High
Wheels	0.329%	High
Body	0.201%	Medium
Electrical	0.194%	Medium
Driveline	0.176%	Medium
Steering	0.109%	Medium
Suspension	0.092%	Medium
Fuel System	0.070%	Low
Frame	0.065%	Low
Axle	0.055%	Low
Engine	0.044%	Low
Transmission	0.039%	Low
Accessories	0.000%	None
Cooling System	0.000%	None
Exhaust	0.000%	None

7.2 Recommendations

This study was based on the assumption that vehicle defects with a strong correlation to accidents should have a strong representation in the OOS criteria. After analyzing the accident data and reviewing the OOS criteria, it appears that the OOS representation is approximately correct.

The next step is to develop a time strategy for the inspection procedure. The time spent inspecting each defect category should be proportionate to the defect category's representation in the accident data. Given a 30 minute inspection period, the data supports the time division presented in Table 7.2.

Table 7.2 Inspection Time Allocation

Top Five Defect Categories	Proportion from OSU sample	Proportion of the Top Five Categories	Time Allocation (minutes)
Brakes	1.665	0.52	15
Tires	0.446	0.14	4
Coupling	0.382	0.12	4
Loading and Securement	0.369	0.12	4
Wheels	0.329	0.10	3
Total	**3.191**	**1.00**	**30**

Despite the fact that items with less crash data validation do not appear on the inspection time allocation table, this does not advocate removing them from the OOS criteria. Therefore, the inspector should continue to place vehicles out of service if the inspector notices a violation of any other OOS criteria. The desired effect would be to spend more time on the items that contribute to accidents and less time on the items that do not contribute.

Other recommendations concern the accident report databases. The following changes would be beneficial to the information gathering process:

1. Uniform reportable accident qualifications for all 50 states
2. Uniform CMV qualifications for all 50 states
3. Uniform defect categories on accident reports for all 50 states
4. Match the defect categories with OOS criteria
5. When accident inspections are performed, do them in accordance with Level I standards.
6. Include the following two check-boxes on accident reports
    1) Indicate if the defect contributed to the accident
    2) Indicate if the officer physically observed the defect

7.3 Future Research

After establishing estimates of mechanical defects contributing to CMV accidents for broad categories (brakes, wheels, etc.), the next research project should determine what defects contribute most heavily within the category. This would provide a basis for the inspection of the mechanical system in question.

The most obvious way to conduct this research would be to extensively cover the detailed accident data found in accident investigation reports. Relative to accident reports, few of these reports exist. Gathering a sufficient number of these reports would involve working closely with many state agencies.

Each agency or jurisdiction has its own set of criteria necessary to warrant an accident investigation report. The variation in accident requirements leads to an undefined accident population. The results could not be used to draw inferences about the general accident population. They could, however, be used to estimate proportions of specific defects, given a more general defect was present. Basically, the goal of future research would be to determine what proportion of the brake defects was attributed to adjustment, drums, shoes, lines, seals, etc. The process would be repeated for the next defect category.

The results from future research could be used in conjunction with results from this study. The time block allotted for the defect category should be divided in the same manner as the entire inspection was divided per defect category.

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APPENDICES

APPENDIX A

Overview of
National Accident Sampling System/
General Estimates System

Overview of National Accident Sampling System/ General Estimates System

Introduction

Traffic accidents and the damage caused by them are a major public concern. One of the main objectives of the National Highway Traffic Safety Administration (NHTSA) is to reduce the cost of these accidents to humans and property. In order to develop and implement plans to reduce this toll, NHTSA must first consider the accidents that occur. In addition, measurement of the accidents is needed to show trends and effects of safety programs.

In governmental fashion, NHTSA has a Research and Development section that contains a branch designated the National Center for Statistics and Analysis (NCSA). NCSA directs the National Accident Sampling System General Estimates System (GES) in an effort to assimilate and analyze crash data [26].

The information sought by NCSA includes accident, vehicle, and human data. The accident data includes time, frequency, location, and actions before and during the accident. Vehicle data accounts for the type of vehicle and the location and extent of damage. Human data covers information such as age, sex, and severity of injuries [27].

Study Design

The GES is a sampling system. With approximately six and one-half million accidents occurring each year, a census is not justifiable. The system is based on a probability sample of around 45,000 police accident reports (PARs) [27].

The GES relies solely on PARs for one major reason: they are easily identified. There are two difficulties with the use of PARs. First, the thresholds between reportable and non-reportable accidents vary between states. A reportable accident in Nevada may not be a reportable accident in Illinois. Second, many accidents go unreported. The majority of these involve only minor property damage and no significant personal injury. In both cases, the more serious accidents will most likely be reported. Therefore, by limiting the concern to police reported accidents, NCSA focuses on the most significant accidents [28].

The PARs provide all of the information necessary for the GES. Once a copy of the report was made, no further information was taken.

The PARs were selected via a complex sampling process. At the fist stage, the nation was split into primary sampling units (PSUs) based on population estimates.

A PSU can be a city, a part of a county, an entire county, or group of counties. These PSUs were organized into strata based on urbanization and geography characteristics.

Selections of the PSUs for the sample were based on the number of fatal and injury crashes in each PSU, according to state publications [27]. This is a probabilities proportional to size (PPS) method where the PSUs with a high number

of fatal and injury crashes are more likely to be selected. Initially, sixty PSUs were selected.

Due to monetary constraints, the GES was designed so that one data collection person could collect the samples from an entire PSU. Because there are many police jurisdictions (PJs) within each PSU, only some of the PJs could be sampled by one person. Therefore, once the PSUs were chosen, it was divided into PJs. An average of seven PJs were selected from each PSU [27]. Again, a probabilities proportional to size (PPS) method was used. This time the selection was based on the total number of accidents reported by the PJ.

After selecting the PSUs and PJs, NCSA figured which and how many accident reports to sample. The accident reports were classified into 4 categories, also called stratums. Three categories depended on accident severity and one category was for medium and heavy trucks. NCSA weighted these categories in order to sample the more serious accidents more intensively. As the more serious accidents occur less frequently, the variance for the accident characteristics would be higher. Therefore, NCSA over-sampled strata 1 and 3. NCSA formulated the percentage of records to collect from each stratum in each PJ. Approximate ratios for 1990, as well as stratum totals are listed in Table A1.

Table A1 1990 GES Accident Report Selection per Stratum

Stratum	1	2	3	4
Category	Towed vehicle, non-truck	Towed vehicle or injury, truck involvement	Injury, non tow, non truck	All others
Selection	1 in every 119	1 in every 16	1 in every 28	1 in every 285
Total	19,021	6,679	6,970	13,620

The last step of data collection occurs when the selected PAR is selected is photocopied and sent to the data coding contractor.

Reliability of Estimates

Due to the complex sampling method, no textbook formulas exist for the calculations of variance. For this reason, the GES utilizes a statistical computer program to estimate variances for every proportional estimate in the GES Report.

Confidence Intervals

The results of the variance calculations provided a basis for confidence intervals. The GES Report lists 68% confidence intervals. This is one standard error by their calculations. Thus, the sample estimates will fall within this interval in 68 out of 100 identical studies. A two standard error interval correlates to a 95% confidence interval for their study [27].

APPENDIX B1

Florida Database

Appendix B1 contains CMV accident data from the state of Florida. Tables B1 and B2 contain the data collected from the accident reports indicating a mechanical defect as a contributing factor. Table B3 groups the accident data into specific defect categories. Tables B4, B5, and B6 sum the accident data into broad categories and give occurrences, proportions, and costs for each of the broad categories.

Table B1: 1993 Florida Accident Report Data

State	1993 Date	Report No.	Truck Type	Listed Defect1	Def. 2	Def. 3	Specific Sub-Item	Other Contrib. Circum.	Injury #1	Inj #2	Inj #3	Driver / Inspector Opinion	Notes from Narrative
FL	1/7/93	30185068	Medium	Brakes			Seal leaking		yes	*	*	Inspector	Car turned in front of truck. Truck skidded left wheels only. Rt rear seal leaking fluid. No pedal resistance.
FL	1/27/93	30129328	Tractor trailer	brakes					yes	yes	yes	N/A	Brakes on trailer locked up. Truck stopped. Rear-ended.
	3/19/93	31146658	medium	brakes					yes	*	*	driver	Round corner. Left skid marks with outside tires only.
FL	3/25/93	31070861	Medium	brakes					Yes	*	*	Driver	Truck "attempted to stop, the brakes malfunctioned."
FL	3/28/93	30435818	Medium	brakes					Yes	yes	*	driver	Driver said no pedal pressure. Pumped brakes several times.
FL	4/2/93	30986348	Medium	brakes					*	*	*	Driver	Driver said rear brakes inoperative prior to accident. Ran off road.
FL	4/26/93	300933768	Tractor trailer	brakes					yes	*	*	inspector	Pedestrian walked in front. Brake defect only noted in check box.
FL	5/17/93	31764410	Medium	brakes					yes	*	*	driver & witness	Driver pumped brakes. "causing the air compression to be gone." Witness heard air brakes 4 or 5 times
FL	6/25/93	30379551	Medium	brakes					yes	*	*	?	Brakes failed. Hit stopped vehicle.
FL	6/28/93	30138148	Medium	brakes					*	*	*	?	Brakes failed. Vehicle tried to turn. Rolled over.
FL	8/3/93	30875233	Medium	Brakes					*	*	*	Inspector	Truck turning left. Left rear wheels locked up before enter intersection. Right rears locked up after entered.
FL	8/30/93	30877454	Medium	Brakes					Yes	*	*	no comment	Rear end accident.
FL	9/2/93	31764334	Medium	brakes					*	*	*	driver	Rear-end accident. Driver knew brakes not working properly.
FL	10/19/93	31440939	Medium	brakes					*	*	*	?	Unable to stop due to defective brakes.
FL	10/22/93	31233954	medium	brakes					Yes	*	*	?	"attempted to stop. Brakes failed."
FL	11/9/93	31178047	Medium	brakes					*	*	*	driver	Tried to stop. Brakes failed. Crashed.
FL	11/30/93	31705273	Heavy	brakes					Yes	*	*	?	"applied brakes to stop. Brakes failed"
FL	7/13/93	31234251	Tractor trailer	drive shaft					*	*	*	N/A	Drive shaft came off. Hit by other vehicles
FL	5/6/93	31572667	Tractor trailer	Load securement					*	*	*	Inspector	Round corner. Tie down broke. Load spilled.

Table B1: 1993 Florida Accident Report Data

State	1993 Date	Report No.	Truck Type	Listed Defect1	Def. 2	Def. 3	Specific Sub-Item	Other Contrib. Circum.	Injury #1	Inj #2	Inj #3	Driver / Inspector Opinion	Notes from Narrative
FL	7/19/93	3012676	Heavy	load securement					yes	*	*	N/A	Part of load fell out. Hit by other vehicles.
FL	7/20/93	31323508	Tractor trailer	load securement					*	*	*	N/A	Part of load fell out of trailer. Hit by other vehicle
FL	8/16/93	31234270	tractor trailer	Other 1					Yes	*	*	Inspector	Truck leaking "an oil like substance" onto road. Car hit oil & spun out.
	7/30/93	30242934	Medium	Other 2					yes	*	*	driver	"Popped out of gear" while parked. Hit pedestrian.
FL	1/19/93	30064113	Garbage	Parking Brake			Parking brk		yes	*	*	Driver	Truck stopped. Driver set brake and climbing out of truck. Truck rolled into pedestrian.
FL	7/22/93	31095788	Heavy	Parking brake					*	*	*	driver	Truck parked. Driver said he set brake. Truck rolled into another car.
FL	2/1/93	30302666	Medium	Tail lights			tail & brake	truck stalled	yes	*	*	Inspector	No rear lights (brake or tail). Truck stalled. Rear-ended.
FL	10/28/93	30387924	Heavy	Tail lights					Yes	*	*	Inspector	Truck rear-ended vehicle. Truck cited for defective lights.
FL	5/3/93	30273759	Heavy	tire					*	*	*	N/A	Front tire blew. Truck hit guard rail.
FL	7/6/93	30122363	Heavy	tire					yes	*	*	N/A	Front tire separated from rim. Caused wreck.
FL	10/20/93	31316349	tractor trailer	tire					yes	*	*	inspector	Front tire on truck went flat. Truck pulled to emergency lane to fix. CMV hit by car.
FL	8/13/93	30188506	Medium	tires			worn		Yes	*	*	Inspector	Rear tires locked up under braking "due to worn tires."
FL	9/5/93	30435931	tractor trailer	transmission				Cocaine in car.	fatal	fatal	*	inspector	Truck tranny locked up. Driver put reflector triangles up. Car ran through reflectors & hit truck.
FL	3/10/93	30970671	Medium	Turn signal				Improper passing	yes	*	*	Inspector	Defective turn signal. Turned into passing car.
FL	12/3/93	30562702	tractor trailer	unknown					fatal	fatal	*	inspector	Truck broken down for unknown reason. Car stopped to help. Hit by another vehicle.

Other 1: "Popped out of gear" while parked.
Other 2: Leaking oil

Medium truck: 4 rear tires
Heavy truck: 2 or more rear axles

Table B2: 1994 Florida Accident Report Data

State	1994 Date	Report No.	Truck Type	Listed Defect1	Def. 2	Def. 3	Specific Sub-Item	Other Contrib. Circum.	Injury #1	Inj #2	Inj #3	Driver / Inspector Opinion	Notes from Narrative
FL	6/13/94	112744669	medium	brake lights			brake lights		yes			inspector	Car rear ended truck. Car driver said no brake lights on truck. Inspector verified.
FL	1/6/94	32347603	Medium	brakes					yes	*	*	inspector	Rear end accident. Officer inspected brakes found them "defective."
FL	2/4/94	30821137	Heavy	brakes					yes	*	*	?	Brakes failed as truck approached intersection. Went around stopped car and into intersection. Hit another car.
FL	3/7/94	31691731	medium	brakes					yes	*	*	both	Driver said brakes "failed to grab." Inspector noted "skid marks were inconsistent with weight and normal skid drag."
FL	5/13/94	31375477	Heavy	brakes					yes	*	*	driver	Driver said "brakes went out." Hit other vehicle.
FL	5/23/94	31615334	Medium	brakes					*	*	*	both	Driver knew brakes defective. Officer observed skid marks from only left side.
FL	7/6/94	30315139	Heavy	brakes					yes	*	*	driver	Driver said no brakes. "Downshifted and took evasive action." Wrecker mechanic did not find a brake problem.
FL	12/22/94	31320332	medium	brakes					yes	*	*	inspector	Left front brake cylinder leaking fluid. No pressure.
FL	4/22/94	30363805	tractor trailer	debris					*	*	*	N/A	Spare tire detached from rear of semi trailer. Hit other vehicle.
FL	11/11/94	30829675	Heavy	drive shaft	tire				yes	*	*	inspector	drive shaft fell out. Hit two tires causing them to blow. Crash ensued.
FL	5/30/94	30190417	Heavy	driveline					yes			N/A	Part of driveline fell out and hit car.
FL	11/16/94	31954736	Medium	electrical					yes	*	*	inspector	CMV disabled due to electrical failure. Hit by car.
FL	7/1/94	32236737	tractor trailer	engine fire					*			N/A	Engine caught on fire.
FL	9/28/94	31673751	Heavy	frame					yes			inspector	"Metal fatigue or fractures prior to the crash." Tub carrying cement broke from frame and caused vehicle to roll over.
FL	1/17/94	30881732	Heavy	other 1					yes	*	*	inspector	Truck driven with dumpster forks in up position. Safety feature to prevent this not functioning.

Table B2: 1994 Florida Accident Report Data

State	1994 Date	Report No.	Truck Type	Listed Defect1	Def. 2	Def. 3	Specific Sub-Item	Other Contrib. Circum.	Injury #1	Inj #2	Inj #3	Driver / Inspector Opinion	Notes from Narrative
FL	12/21/94	31225718	Medium	other 2					yes	*	*	inspector	Bolt holding tow strap failed. Towed vehicle came loose.
FL	7/26/94	31108037	tractor trailer	parking brake			park. brake		*			driver	Truck not running. Parking brake set. Rolled down hill. Hit sign.
FL	3/4/94	30403872	Medium	securement					*	*	*	N/A	Ladder slid off of truck. Hit car.
FL	6/23/94	31515056	tractor trailer	securement					*			N/A	Part of load fell off. Hit other vehicle.
FL	12/8/94	31038921	Heavy	securement					yes	*	*	N/A	Part of load fell out. Hit by car.
FL	10/22/94	31572708	tractor trailer	tail lights			tail lights		yes	*	*	driver	Car struck improperly parked truck. Car driver said no lights on trailer.
FL	5/23/94	30707003	tractor trailer	tire					*			N/A	Tire blew on cab. Caused wreck.
FL	7/11/94	31408020	heavy	tire					yes			N/A	Tire blew. Caused wreck.
FL	8/19/94	31332401	Medium	tire			worn		*			Inspector	Worn front tires. Different type, and tread. Light rain. Unable to stop in straight line.
FL	10/20/94	40753714	Heavy	tire					yes			N/A	Tire blew. Caused wreck.
FL	12/9/94	30484071	Tractor trailer	tires					yes	*	*	N/A	Trailer tire blew. Wreck ensued.
FL	8/26/94	30682382	Heavy	transmission					yes			both	Tranny exploded. Caused tires to lock up. Caused wreck.
FL	2/24/94	31233974	Medium	unknown					yes	*	*	inspector	Truck stopped in lane due to unknown defect. Hit by car.
FL	3/7/94	31016003	medium	unknown					*	*	*	N/A	Truck broken down in road. Hit by other truck. Breakdown defect not listed.
FL	4/27/94	30849702	tractor trailer	unknown					*	*	*	driver	driver "heard a noise under his vehicle which caused his vehicle to run off" of road. Hit sign. Rolled over.
FL	11/12/94	40505573	tractor trailer	unknown					yes	yes	*	inspector	CMV disabled due to unknown defect in lane. Hit by car.
FL	11/15/94	30936666	tractor trailer	wheel bearing					yes	*	*	inspector	"wheel bearing froze up causing the wheel and tire to leave the vehicle"

Other 1: safety device not operating
Other 2: Bolt holding tow strap failed

Medium truck: 4 rear tires
Heavy truck: 2 or more rear axles

Table B3: 1993 and 1994 Florida Data by Specific Defect

	Source	FL				
	Sample Size	1500				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Accessories	Gauges (all)	0				0
Accessories	Horn	0				0
Accessories	Hydraulic lift	0				0
Accessories	Other or unknown	0				0
Accessories	Speedometer	0				0
Accessories	Windshield wiper control	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Axle	Adjustable	0				0
Axle	Axle shaft broken	0				0
Axle	Fell off	0				0
Axle	Multi-speed mechanisms	0				0
Axle	Non-drive	0				0
Axle	Other or unknown	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Body	Battery casing	0				0
Body	Cab doors	0				0
Body	Cargo box, van	0				0
Body	Cargo doors, trailer body panels, floor, etc.	0				0
Body	Cargo heater or refrigeration unit	0				0
Body	Cargo tank	0				0
Body	Distance from end of trailer to protection device exceeded.	0				0
Body	Hold-down latch or tilting mechanism	0				0
Body	Interior	0				0
Body	Other or unknown	1		1		96,187
Body	Rear load ramp height	0				0
Body	Spare tire rack	1			1	14,200
Body	Trailer support (landing gear)	0				0
Sum		**2**	**0**	**1**	**1**	**110,387**
Brakes	121 brake system	0				0
Brakes	Adjustment	0				0
Brakes	Air Chambers (Diaphragm)	0				0
Brakes	Air or vacuum booster	0				0
Brakes	Air Valve	0				0
Brakes	Brake linings contaminated	0				0
Brakes	Check valve	0				0
Brakes	Compressor	0				0
Brakes	Couplings (glad hands, etc.)	0				0
Brakes	Cracked lining	0				0
Brakes	Cylinder seal	0				0

Table B3: 1993 and 1994 Florida Data by Specific Defect

	Source	FL				
	Sample Size	1500				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Brakes	Disconnected	0				0
Brakes	Drums	0				0
Brakes	Hydraulic pump or accumulator	0				0
Brakes	Improper installation	0				0
Brakes	Lines	0				0
Brakes	Lining wear	0				0
Brakes	Linings, shoes, fasteners, drum, clevis pin	0				0
Brakes	Low air or vacuum indicator	0				0
Brakes	Master cylinder	0				0
Brakes	Other or unknown	22		15	7	1,542,205
Brakes	Parking brake	3		1	2	124,587
Brakes	Pedal, foot valve	0				0
Brakes	Pressure relief valve	0				0
Brakes	Springs, cams, adjusters, actuator valve	0				0
Brakes	Wheel cylinder	2		2		192,374
Sum		**27**	**0**	**18**	**9**	**1,859,166**
Cooling system	Belt water pump	0				0
Cooling system	Hoses, clamps, cap, thermostat, shutters	0				0
Cooling system	Other or unknown	0				0
Cooling system	Radiator	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Coupling	Breakaway device	0				0
Coupling	Fifth wheel	0				0
Coupling	Fifth wheel kingpin	0				0
Coupling	Fifth wheel plate	0				0
Coupling	Locking and Release mechanism	0				0
Coupling	Mounting, welds, u-bolts	0				0
Coupling	Not properly engaged	0				0
Coupling	Other or unknown	1		1		96,187
Coupling	Pintle Hook	0				0
Coupling	Saddle mount	0				0
Coupling	Spindle broken	0				0
Coupling	Tow bar, ball & socket, etc.	0				0
Sum		**1**	**0**	**1**	**0**	**96,187**
Driveline	Carrier bearings	0				0
Driveline	Differential failure	0				0
Driveline	Fell out (part or all)	3		2	1	206,574
Driveline	Other or unknown	0				0
Driveline	Shaft broke	0				0
Driveline	Universal joints	0				0

Table B3: 1993 and 1994 Florida Data by Specific Defect

	Source	FL				
	Sample Size	1500				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Sum		**3**	**0**	**2**	**1**	**206,574**
Electrical	Battery, cables	0				0
Electrical	Fuses, circuit breakers	0				0
Electrical	Generator, alternator, voltage regulator	0				0
Electrical	Ingnition system	0				0
Electrical	Instruments, controls	0				0
Electrical	Lights, brake	1		1		96,187
Electrical	Lights, head	0				0
Electrical	Lights, other	0				0
Electrical	Lights, reverse	0				0
Electrical	Lights, tail	3		3		288,561
Electrical	Lights, turn and hazard	1		1		96,187
Electrical	Other or unknown	1		1		96,187
Electrical	Wiring (Cargo area)	0				0
Electrical	Wiring (power unit)	0				0
Sum		**6**	**0**	**6**	**0**	**577,122**
Engine	Air blower	0				0
Engine	Crankshaft, internals	0				0
Engine	Flywheel, vib. dampener	0				0
Engine	Oil pump, lube system	0				0
Engine	Other or Unknown	1			1	14,200
Engine	Timing gear	0				0
Engine	Valve train	0				0
Sum		**1**	**0**	**0**	**1**	**14,200**
Exhaust	Exhaust pipe, hangers	0				0
Exhaust	Other or unknown	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Frame	Cross members	0				0
Frame	Other or Unknown	0				0
Frame	Rails and reinforcement	1		1		96,187
Frame	Rivets, bolts, welds	0				0
Frame	Stabilizer Bars	0				0
Sum		**1**	**0**	**1**	**0**	**96,187**
Fuel System	Carburetor	0				0
Fuel System	Fuel filters	0				0
Fuel System	Fuel lines, valves	0				0
Fuel System	Fuel pump	0				0
Fuel System	Fuel tank	0				0
Fuel System	Injection pump	0				0
Fuel System	Other or unknown	0				0
Fuel System	Throttle linkage	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Load Securement	Baffles (cargo tank)	0				0
Load Securement	Battery casing fell off	0				0
Load Securement	Bolts holding tank failed	0				0
Load Securement	Bracing (metal rolls)	0				0
Load Securement	Other or Unknown	0				0

Table B3: 1993 and 1994 Florida Data by Specific Defect

	Source	FL				
	Sample Size	1500				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Load Securement	Part of load fell out	5		2	3	234,974
Load Securement	Tie downs, chains, etc.	1			1	14,200
Sum		**6**	**0**	**2**	**4**	**249,174**
Other or Unknown		7	1	4	2	3,967,087
Sum		**7**	**1**	**4**	**2**	**3,967,087**
Steering	Ball & socket	0				0
Steering	Disconnected from box	0				0
Steering	gear	0				0
Steering	linkage, drag link, tie rod	0				0
Steering	Other or unknown	0				0
Steering	power steering system	0				0
Steering	Steering box loose	0				0
Steering	Steering wheel, column shaft	0				0
Steering	Tie rod (loose)	0				0
Sum		0	0	0	0	0
Suspension	Air bags, controls, piping	0				0
Suspension	Arms, torque, rods, walking beams	0				0
Suspension	Bushings, pivots, bearings	0				0
Suspension	Other or unknown	0				0
Suspension	Shackle, pin, hanger	0				0
Suspension	Shocks and mountings	0				0
Suspension	Spring	0				0
Suspension	Torsion bars, stabilizer, mountings	0				0
Suspension	U-bolts holding spring	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Tires	Blowout	7		5	2	509,335
Tires	Low pressure	0				0
Tires	Original tread	0				0
Tires	Other or unknown	0				0
Tires	Overloaded	0				0
Tires	Recap or retread	0				0
Tires	Sidewall separation	0				0
Tires	Tread, worn	2		1	1	110,387
Tires	Tread separation	0				0
Tires	Tube, or tube valve	0				0
Sum		**9**	**0**	**6**	**3**	**619,722**
Transmission	All auxiliary failures	0				0
Transmission	Automatic tran. internal	0				0
Transmission	Clutch	0				0
Transmission	Clutch linkage	0				0
Transmission	Manual tran. internal	0				0
Transmission	Other or Unknown	2	1	1		3,650,126

Table B3: 1993 and 1994 Florida Data by Specific Defect

	Source	FL				
	Sample Size	1500				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Transmission	Shift controls & linkage	0				0
Sum		**2**	**1**	**1**	**0**	**3,650,126**
Wheels	Leaking grease	0				0
Wheels	Other of Unknown	0				0
Wheels	Rims, flange, ring, hub, fasteners	0				0
Wheels	Studs, lugs, fasteners	0				0
Wheels	Wheel bearings	1		1		96,187
Wheels	Wheel hubs	0				0
Wheels	Wheel spacer	0				0
Sum		**1**	**0**	**1**	**0**	**96,187**
Totals		**66**	**2**	**43**	**21**	**11,542,119**

Table B4: 1993 Florida Data by Defect Category

Sample Size 750

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle		0.00%				0
Back Up Lights		0.00%				0
Brake Lights		0.00%				0
Brakes	17	2.27%		11	6	1,143,257
Coupling		0.00%				0
Debris Falling Off		0.00%				0
Driveshaft	1	0.13%			1	14,200
Dump Activator		0.00%				0
Frame		0.00%				0
Motor Fire		0.00%				0
Other	2	0.27%		2		192,374
Springs		0.00%				0
Steering		0.00%				0
Suspension		0.00%				0
Throttle Sticking		0.00%				0
Tie Rod		0.00%				0
Loading & Securement	3	0.40%		1	2	124,587
Tire	4	0.53%		3	1	302,761
Trailer Door		0.00%				0
Trailer Fire		0.00%				0
Turn Lights	1	0.13%		1		96,187
Unknown	1	0.13%	1			3,553,939
Wheel Bearing		0.00%				0
Wheel Fire		0.00%				0
Wheel Separation		0.00%				0
Head Lights		0.00%				0
Parking Brake	2	0.27%		1	1	110,387
Tail Lights	2	0.27%		2		192,374
Transmission	1	0.13%	1			3,553,939
Electrical		0.00%				0
TOTALS	**34**	**4.53%**	**2**	**21**	**11**	**9284005**

Table B5: 1994 Florida Data by Defect Category

Sample Size 750

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle		0.00%				0
Back Up Lights		0.00%				0
Brake Lights	1	0.13%		1		96,187
Brakes	7	0.93%		6	1	591,322
Coupling		0.00%				0
Debris Falling Off	1	0.13%			1	14,200
Driveshaft	2	0.27%		2		192,374
Dump Activator		0.00%				0
Frame	1	0.13%		1		96,187
Motor Fire	1	0.13%			1	14,200
Other	2	0.27%		2		192,374
Springs		0.00%				0
Steering		0.00%				0
Suspension		0.00%				0
Throttle Sticking		0.00%				0
Tie Rod		0.00%				0
Loading & Securement	3	0.40%		1	2	124,587
Tire	5	0.67%		3	2	316,961
Trailer Door		0.00%				0
Trailer Fire		0.00%				0
Turn Lights		0.00%				0
Unknown	4	0.53%		2	2	220,774
Wheel Bearing	1	0.13%		1		96,187
Wheel Fire		0.00%				0
Wheel Separation		0.00%				0
Head Lights		0.00%				0
Parking Brake	1	0.13%			1	14,200
Tail Lights	1	0.13%		1		96,187
Transmission	1	0.13%		1		96,187
Electrical	1	0.13%		1		96,187
TOTALS	**32**	**4.27%**	**0**	**22**	**10**	**2,258,114**

Other 1: safety device not operating
Other 2: Bolt holding tow strap failed

Unknown: 1, 2, 3 Truck broken down (due to unknown reasons) and hit
4 Driver heard noise. Truck veered off of roadway.

Table B6: 1993 and 1994 Florida Data by Defect Category

Sample Size 1500

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle	0	0.00%	0	0	0	0
Back Up Lights	0	0.00%	0	0	0	0
Brake Lights	1	0.07%	0	1	0	96,187
Brakes	24	1.60%	0	17	7	1,734,579
Coupling	0	0.00%	0	0	0	0
Debris Falling Off	1	0.07%	0	0	1	14,200
Driveshaft	3	0.20%	0	2	1	206,574
Dump Activator	0	0.00%	0	0	0	0
Frame	1	0.07%	0	1	0	96,187
Motor Fire	1	0.07%	0	0	1	14,200
Other	4	0.27%	0	4	0	384,748
Springs	0	0.00%	0	0	0	0
Steering	0	0.00%	0	0	0	0
Suspension	0	0.00%	0	0	0	0
Throttle Sticking	0	0.00%	0	0	0	0
Tie Rod	0	0.00%	0	0	0	0
Loading & Securement	6	0.40%	0	2	4	249,174
Tire	9	0.60%	0	6	3	619,722
Trailer Door	0	0.00%	0	0	0	0
Trailer Fire	0	0.00%	0	0	0	0
Turn Lights	1	0.07%	0	1	0	96,187
Unknown	5	0.33%	1	2	2	3,774,713
Wheel Bearing	1	0.07%	0	1	0	96,187
Wheel Fire	0	0.00%	0	0	0	0
Wheel Separation	0	0.00%	0	0	0	0
Head Lights	0	0.00%	0	0	0	0
Parking Brake	3	0.20%	0	1	2	124,587
Tail Lights	3	0.20%	0	3	0	288,561
Transmission	2	0.13%	1	1	0	3,650,126
Electrical	1	0.07%	0	1	0	96,187
TOTALS	**66**	**4.40%**	**2**	**43**	**21**	**11,542,119**

APPENDIX B2

Ohio Database

Appendix B2 contains CMV accident data from the state of Ohio. Tables B7 and B8 contain the data collected from the accident reports indicating a mechanical defect as a contributing factor. Table B9 groups the accident data into specific defect categories. Tables B10, B11, and B12 sum the accident data into broad categories and give occurrences, proportions, and costs for each of the broad categories.

Table B7: 1993 Ohio Accident Report Data

State	1993 Date	Report No.	Truck Type	Listed Defect 1	Listed Defect 2	Listed Defect 3	Specific Sub-Item	Other Contrib. Circum.	Inj. #1	Inj. #2	Inj. #3	Driver / Inspector Opinion	Notes from Narrative
OH	34250	932731478	Chevy panel van	back-up lights	*	*	none	*	*	*	*	Inspector	Truck backed up into car. No reverse lights.
OH	4/23/93	930531432	Ford F700 Dump	brakes	*	*	wheel cylinder	*	yes	*	*	Inspector	Wheel cylinder broke on RR, causing loss of brakes
OH	10/7/93	931200991	International Tanieer ?	brakes	*	*	none	*	*	*	*	Driver / Inspector	Brakes did not work, emergency did not stop vehicle
OH	34198	2301087	Ford straight (OTHT)	brakes	*	*	none	*	Yes	*	*	Inspector	Brakes apparently failed. Truck did not stop at bottom of hill.
OH	6/15/93	930730251	Ford L8000 strght	cargo door opened	*	*	none	*	*	*	*	Inspector	Side cargo door opened and hit another vehicle
OH	11/17/93	931400943	International Loaditor ?	coupling	*	*	none	*	*	*	*	Inspector	Trailer disconnected and hit parked car. Non-semi towing portable generator.
OH	1/3/93	2010215	Peterbuilt semi (OTHT)	coupling	*	*	none	*	*	*	*	Inspector	Trailer disconnected from tractor
OH	4--24-93	930540172	Mack straight truck	driveshaft	*	*	none	*	*	*	*	Inspector	Part of driveshaft fell onto road
OH	7/2/93	930921281	Chevy C-1500	driveshaft	*	*	none	*	*	*	*	Inspector	Driveshaft broke, truck rolled back into other vehicle
OH	8/2/93	930990895	Mack Econoline P686St Dump	Dump activator	*	*	PTO dump activator	*	*	*	*	Driver / Inspector	Bed on dump trailer rose while vehicle moving, hit wire above road
OH	1/8/93	2260579	International Dump (OTHT)	Dump activator	*	*	hydraulics?	*	Yes	*	*	Inspector	Bed raised up and hit bridge
OH	12/6/93	931641247	Mack Econodyne	tire	*	*	blowout	*	*	*	*	Inspector	Debris from blowout hit other car
OH	34225	932720958	Ford Econoline 350 panel van	tire	*	*	tread separation	*	*	*	*	Inspector	Tread separated from tire, truck went into ditch
OH	9/12/93	2350745	Tractor Trailer	Unknown	*	*	none	*	*	*	*	Inspector	Unit struck phone and cable line, pulling them down.
OH	8/31/93	2330633	Tractor Trailer	Unknown	*	*	none	*	*	*	*	Inspector	Unit slowed to a stop. Hit by other vehicle.
OH	5/7/93	930530689	GMC 35 Straight truck	wheel separation	*	*	none	*	yes	*	*	Inspector	Duels came off one side of truck

Unknown: Not given in report.

Table B8: 1994 Ohio Accident Report Data

State	1994 Date	Report No.	Truck Type	Listed Defect 1	Listed Defect 2	Listed Defect 3	Specific Sub-Item	Other Contrib. Circum.	Inj. #1	Inj. #2	Inj. #3	Driver / Inspector Opinion	Notes from Narrative
OH	9/13/94	942190562	International semi (OTHT)	brake	*	*	none	*	*	*	*	inspector	"left rear trailer brake caught fire"
OH	4/21/94	940440284	Isuzu Straight truck	brakes	*	*	none	*	yes	*	*	driver/inspector	Stopped once. When tried again, brakes went out.
OH	8/18/94	940980241	International garbage	brakes	*	*	none	*	yes	*	*	driver	"failed to stop in assured safe distance"
OH	10/18/94	941241118	Ford 9000 dump	brakes	*	*	none	*	*	*	*	inspector	front brakes locked up, caused wreck
OH	11/11/94	942470289	Ford L8000 (OTHT)	brakes	*	*	none	*	yes	*	*	driver/inspector	"for unknown reason, brakes failed to work"
OH	6/7/94	940690560	Chev C-15 straight	coupling	*	*	none	*	*	*	*	inspector	trailer came off, hit pole
OH	9/1/94	942380362	Kenworth (OTHT)	coupling	*	*	none	*	*	*	*	inspector	trailer came off
OH	6/1/94	94074034	tractor w/ semi trailer	driveshaft	*	*	none	*	*	*	*	driver/inspector	drive shaft came off, hit other vehicle
OH	10/17/94	941210777	Ford F600 straight	tailgate fell off	*	*	none	*	*	*	*	inspector	tailgate fell off, hit other vehicle
OH	4/4/94	942170413	Ford semi (OTHT)	wheel fire	*	*	none	*	*	*	*	inspector	"left rear trailer axle caught fire"
OH	3/3/94	940600165	GMC straight truck	wheel separation	*	*	none	*	*	*	*	inspector	"tire broke loose" causing loss of control

Table B9: 1993 and 1994 Ohio Data by Specific Defect

	Source	OH				
	Sample Size	1011				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Accessories	Gauges (all)	0				0
Accessories	Horn	0				0
Accessories	Hydraulic lift	0				0
Accessories	Other or unknown	0				0
Accessories	Speedometer	0				0
Accessories	Windshield wiper control	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Axle	Adjustable	0				0
Axle	Axle shaft broken	0				0
Axle	Fell off	0				0
Axle	Multi-speed mechanisms	0				0
Axle	Non-drive	0				0
Axle	Other or unknown	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Body	Battery casing	0				0
Body	Cab doors	0				0
Body	Cargo box, van	0				0
Body	Cargo doors, trailer body panels, floor, etc.	2			2	28,400
Body	Cargo heater or refrigeration unit	0				0
Body	Cargo tank	0				0
Body	Distance from end of trailer to protection device exceeded.	0				0
Body	Hold-down latch or tilting mechanism	0				0
Body	Interior	0				0
Body	Other or unknown	2		1	1	110,387
Body	Rear load ramp height	0				0
Body	Spare tire rack	0				0
Body	Trailer support (landing gear)	0				0
Sum		**4**	**0**	**1**	**3**	**138,787**
Brakes	121 brake system	0				0
Brakes	Adjustment	0				0
Brakes	Air Chambers (Diaphragm)	0				0
Brakes	Air or vacuum booster	0				0
Brakes	Air Valve	0				0
Brakes	Brake linings contaminated	0				0
Brakes	Check valve	0				0
Brakes	Compressor	0				0
Brakes	Couplings (glad hands, etc.)	0				0
Brakes	Cracked lining	0				0
Brakes	Cylinder seal	0				0

Table B9: 1993 and 1994 Ohio Data by Specific Defect

	Source	OH				
	Sample Size	1011				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Brakes	Disconnected	0				0
Brakes	Drums	0				0
Brakes	Hydraulic pump or accumulator	0				0
Brakes	Improper installation	0				0
Brakes	Lines	0				0
Brakes	Lining wear	0				0
Brakes	Linings, shoes, fasteners, drum, clevis pin	0				0
Brakes	Low air or vacuum indicator	0				0
Brakes	Master cylinder	0				0
Brakes	Other or unknown	7		4	3	427,348
Brakes	Parking brake	0				0
Brakes	Pedal, foot valve	0				0
Brakes	Pressure relief valve	0				0
Brakes	Springs, cams, adjusters, actuator valve	0				0
Brakes	Wheel cylinder	1		1		96,187
Sum		**8**	**0**	**5**	**3**	**523,535**
Cooling system	Belt water pump	0				0
Cooling system	Hoses, clamps, cap, thermostat, shutters	0				0
Cooling system	Other or unknown	0				0
Cooling system	Radiator	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Coupling	Breakaway device	0				0
Coupling	Fifth wheel	0				0
Coupling	Fifth wheel kingpin	0				0
Coupling	Fifth wheel plate	0				0
Coupling	Locking and Release mechanism	0				0
Coupling	Mounting, welds, u-bolts	0				0
Coupling	Not properly engaged	0				0
Coupling	Other or unknown	4			4	56,800
Coupling	Pintle Hook	0				0
Coupling	Saddle mount	0				0
Coupling	Spindle broken	0				0
Coupling	Tow bar, ball & socket, etc.	0				0
Sum		**4**	**0**	**0**	**4**	**56,800**
Driveline	Carrier bearings	0				0
Driveline	Differential failure	0				0
Driveline	Fell out (part or all)	2			2	28,400
Driveline	Other or unknown	0				0
Driveline	Shaft broke	1			1	14,200
Driveline	Universal joints	0				0

Table B9: 1993 and 1994 Ohio Data by Specific Defect

	Source	OH				
	Sample Size	1011				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Sum		**3**	**0**	**0**	**3**	**42,600**
Electrical	Battery, cables	0				0
Electrical	Fuses, circuit breakers	0				0
Electrical	Generator, alternator, voltage regulator	0				0
Electrical	Ingnition system	0				0
Electrical	Instruments, controls	0				0
Electrical	Lights, brake	0				0
Electrical	Lights, head	0				0
Electrical	Lights, other	0				0
Electrical	Lights, reverse	1			1	14,200
Electrical	Lights, tail	0				0
Electrical	Lights, turn and hazard	0				0
Electrical	Other or unknown	0				0
Electrical	Wiring (Cargo area)	0				0
Electrical	Wiring (power unit)	0				0
Sum		**1**	**0**	**0**	**1**	**14,200**
Engine	Air blower	0				0
Engine	Crankshaft, internals	0				0
Engine	Flywheel, vib. dampener	0				0
Engine	Oil pump, lube system	0				0
Engine	Other or Unknown	0				0
Engine	Timing gear	0				0
Engine	Valve train	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Exhaust	Exhaust pipe, hangers	0				0
Exhaust	Other or unknown	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Frame	Cross members	0				0
Frame	Other or Unknown	0				0
Frame	Rails and reinforcement	0				0
Frame	Rivets, bolts, welds	0				0
Frame	Stabilizer Bars	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Fuel System	Carburetor	0				0
Fuel System	Fuel filters	0				0
Fuel System	Fuel lines, valves	0				0
Fuel System	Fuel pump	0				0
Fuel System	Fuel tank	0				0
Fuel System	Injection pump	0				0
Fuel System	Other or unknown	0				0
Fuel System	Throttle linkage	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Load Securement	Baffles (cargo tank)	0				0
Load Securement	Battery casing fell off	0				0
Load Securement	Bolts holding tank failed	0				0
Load Securement	Bracing (metal rolls)	0				0
Load Securement	Other or Unknown	0				0

Table B9: 1993 and 1994 Ohio Data by Specific Defect

	Source	OH				
	Sample Size	1011				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Load Securement	Part of load fell out	0				0
Load Securement	Tie downs, chains, etc.	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Other or Unknown		2			2	28,400
Sum		**2**	**0**	**0**	**2**	**28,400**
Steering	Ball & socket	0				0
Steering	Disconnected from box	0				0
Steering	gear	0				0
Steering	linkage, drag link, tie rod	0				0
Steering	Other or unknown	0				0
Steering	power steering system	0				0
Steering	Steering box loose	0				0
Steering	Steering wheel, column shaft	0				0
Steering	Tie rod (loose)	0				0
Sum		0	0	0	0	0
Suspension	Air bags, controls, piping	0				0
Suspension	Arms, torque, rods, walking beams	0				0
Suspension	Bushings, pivots, bearings	0				0
Suspension	Other or unknown	0				0
Suspension	Shackle, pin, hanger	0				0
Suspension	Shocks and mountings	0				0
Suspension	Spring	0				0
Suspension	Torsion bars, stabilizer, mountings	0				0
Suspension	U-bolts holding spring	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Tires	Blowout	1			1	14,200
Tires	Low pressure	0				0
Tires	Original tread	0				0
Tires	Other or unknown	0				0
Tires	Overloaded	0				0
Tires	Recap or retread	0				0
Tires	Sidewall separation	0				0
Tires	Tread, worn	0				0
Tires	Tread separation	1			1	14,200
Tires	Tube, or tube valve	0				0
Sum		**2**	**0**	**0**	**2**	**28,400**
Transmission	All auxiliary failures	0				0
Transmission	Automatic tran. internal	0				0
Transmission	Clutch	0				0
Transmission	Clutch linkage	0				0
Transmission	Manual tran. internal	0				0
Transmission	Other or Unknown	0				0

Table B9: 1993 and 1994 Ohio Data by Specific Defect

	Source	OH				
	Sample Size	1011				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Transmission	Shift controls & linkage	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Wheels	Leaking grease	0				0
Wheels	Other of Unknown	3		1	2	124,587
Wheels	Rims, flange, ring, hub, fasteners	0				0
Wheels	Studs, lugs, fasteners	0				0
Wheels	Wheel bearings	0				0
Wheels	Wheel hubs	0				0
Wheels	Wheel spacer	0				0
Sum		**3**	**0**	**1**	**2**	**124,587**
Totals		**27**	**0**	**7**	**20**	**957,309**

Table B10: 1993 Ohio Data by Defect Category

Sample Size 506

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle		0.00%				0
Back Up Lights	1	0.20%			1	14,200
Brake Lights		0.00%				0
Brakes	3	0.59%		2	1	206,574
Coupling	2	0.40%			2	28,400
Debris Falling Off		0.00%				0
Driveshaft	2	0.40%			2	28,400
Dump Activator	2	0.40%		1	1	110,387
Frame		0.00%				0
Motor Fire		0.00%				0
Other		0.00%				0
Springs		0.00%				0
Steering		0.00%				0
Suspension		0.00%				0
Throttle Sticking		0.00%				0
Tie Rod		0.00%				0
Loading & Securement		0.00%				0
Tire	2	0.40%			2	28,400
Trailer Door	1	0.20%			1	14,200
Trailer Fire		0.00%				0
Turn Lights		0.00%				0
Unknown	2	0.40%			2	28,400
Wheel Bearing		0.00%				0
Wheel Fire		0.00%				0
Wheel Separation	1	0.20%		1		96,187
Head Lights		0.00%				0
Parking Brake		0.00%				0
Tail Lights		0.00%				0
Transmission		0.00%				0
Electrical		0.00%				0
TOTALS	**16**	**3.16%**	**0**	**4**	**12**	**555,148**

Other:

Unknown:

Table B11: 1994 Ohio Data by Defect Category

Sample Size 505

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle		0.00%				0
Back Up Lights		0.00%				0
Brake Lights		0.00%				0
Brakes	5	0.99%		3	2	316,961
Coupling	2	0.40%			2	28,400
Debris Falling Off		0.00%				0
Driveshaft	1	0.20%			1	14,200
Dump Activator		0.00%				0
Frame		0.00%				0
Motor Fire		0.00%				0
Other		0.00%				0
Springs		0.00%				0
Steering		0.00%				0
Suspension		0.00%				0
Throttle Sticking		0.00%				0
Tie Rod		0.00%				0
Loading & Securement		0.00%				0
Tire		0.00%				0
Trailer Door	1	0.20%			1	14,200
Trailer Fire		0.00%				0
Turn Lights		0.00%				0
Unknown		0.00%				0
Wheel Bearing		0.00%				0
Wheel Fire	1	0.20%			1	14,200
Wheel Separation	1	0.20%			1	14,200
Head Lights		0.00%				0
Parking Brake		0.00%				0
Tail Lights		0.00%				0
Transmission		0.00%				0
Electrical		0.00%				0
TOTALS	**11**	**2.18%**	**0**	**3**	**8**	**402,161**

Other:

Unknown:

Table B12: 1993 and 1994 Ohio Data by Defect Category

Sample Size 1011

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle	0	0.00%	0	0	0	0
Back Up Lights	1	0.10%	0	0	1	14,200
Brake Lights	0	0.00%	0	0	0	0
Brakes	8	0.79%	0	5	3	523,535
Coupling	4	0.40%	0	0	4	56,800
Debris Falling Off	0	0.00%	0	0	0	0
Driveshaft	3	0.30%	0	0	3	42,600
Dump Activator	2	0.20%	0	1	1	110,387
Frame	0	0.00%	0	0	0	0
Motor Fire	0	0.00%	0	0	0	0
Other	0	0.00%	0	0	0	0
Springs	0	0.00%	0	0	0	0
Steering	0	0.00%	0	0	0	0
Suspension	0	0.00%	0	0	0	0
Throttle Sticking	0	0.00%	0	0	0	0
Tie Rod	0	0.00%	0	0	0	0
Loading & Securement	0	0.00%	0	0	0	0
Tire	2	0.20%	0	0	2	28,400
Trailer Door	2	0.20%	0	0	2	28,400
Trailer Fire	0	0.00%	0	0	0	0
Turn Lights	0	0.00%	0	0	0	0
Unknown	2	0.20%	0	0	2	28,400
Wheel Bearing	0	0.00%	0	0	0	0
Wheel Fire	1	0.10%	0	0	1	14,200
Wheel Separation	2	0.20%	0	1	1	110,387
Head Lights	0	0.00%	0	0	0	0
Parking Brake	0	0.00%	0	0	0	0
Tail Lights	0	0.00%	0	0	0	0
Transmission	0	0.00%	0	0	0	0
Electrical	0	0.00%	0	0	0	0
TOTALS	**27**	**2.67%**	**0**	**7**	**20**	**957,309**

Other:

Unknown:

APPENDIX B3

Missouri Database

Appendix B3 contains CMV accident data from the state of Missouri. Tables B13 and B14 contain the data collected from the accident reports indicating a mechanical defect as a contributing factor. Table B15 groups the accident data into specific defect categories. Tables B16, B17, and B18 sum the accident data into broad categories and give occurrences, proportions, and costs for each of the broad categories.

Table B13: 1993 Missouri Accident Report Data

State	1993 Date	Report No.	Truck Type	Listed Defect1	Defect 2	Specific Sub-Item	Contributing Circumstance	Injury #1	Injury #2	Injury #3	Driver/ Inspector Opinion	Notes from Narrative
MO	7/28/93	94605	Straight truck	accelerator	brakes		inattention	none	*	*	driver	Driver stated that upon releasing foot from the gas pedal, the throttle stuck. Throwing the truck in neutral, he applied brakes which locked up and overturned truck.
MO	7/20/93	5028	Straight truck	axle	*		none	none	*	*	driver	Rear axle broke just to the right of left duels. Used axle had apparently been put on shortly before incident.
MO	4/2/93	25822	Tractor trailer	brakes	*		none	none	*	*	driver	Driver stated that his brakes failed as he attempted to slow to avoid striking vehicle in front.
MO	5/1/93	359	Straight truck	brakes	*		none	none	*	*	driver	Driver stated that his brakes failed as he attempted to slow when approaching another vehicle.
MO	7/3/93	933604	Straight truck	brakes	*		none	none	*	*	driver	Driver stated that his brakes failed as he attempted to slow when approaching another vehicle.
MO	7/22/93	9314572	Straight truck	brakes	*		none	probabl	probable	*	driver	Vehicle struck rear of second vehicle that had stopped for traffic. Driver stated that brakes had failed.
MO	10/6/93	154558	Straight truck	brakes	*		none	none	*	*	driver	Vehicle struck rear of second vehicle that had stopped for traffic light. Driver stated his braked failed.
MO	10/6/93	935636	Tractor trailer	brakes	*		wrong side(not passing)	evident	*	*	driver	Driver stated his brakes locked up when applied, causing the truck to spin out of control.
MO	11/16/93	C16649	Straight truck	brakes	*		none	none	*	*	driver	Driver stated his brakes locked up when applied, causing the truck to strike vehicle in front.
MO	9/24/93	C-15416	Straight truck	brakes (electric)	*		none	none	*	*	driver	Driver stated that the electric brake went on and locked up the brakes.
MO	8/19/93	934609	tractor trailer	coupling (spindle)	*	Spindle	none	disablin	*	*	N/A	Trailer disconnected. Driver said spindle broke.
MO	10/26/93	4016	Tractor trailer	coupling device	*		none	none	*	*	driver	Driver stated his second trailer began to swerve uncontrollably causing loss of control.
MO	11/2/93	C-16298	Tractor trailer	coupling device	*		none	none	*	*	driver	Driver stated the tow tongue separated partially from the mobile home trailer

Table B13: 1993 Missouri Accident Report Data

State	1993 Date	Report No.	Truck Type	Listed Defect1	Defect 2	Specific Sub-Item	Contributing Circumstance	Injury #1	Injury #2	Injury #3	Driver/ Inspector Opinion	Notes from Narrative
MO	12/17/95	186363	Tractor trailer	coupling device	*		none	none	*	*	driver	Driver stated that as he attempted to make turn, flatbed trailer broke free from the rest of the vehicle.
MO	3/23/93	C-11404	Tractor trailer	Head lights	*		none	none	*	*	driver	Driver stated that all his lights went out in an apparent electrical failure causing loss of control on a wide turn. Inspector states that all the truck lights were on upon arrival.
MO	9/22/93	9309-406	Straight truck	tie down	*		*	probabl	*	*	officer	Load shifted. Truck overturned.
MO	10/22/93	28183	Tractor trailer	Tie down	*		too fast for conditions	none	*	*	N/A	Load shifted.
MO	11/29/93	936892	Straight truck	tire	*		none	none	*	*	driver	Driver stated that a tire blew (recap) causing loss of control.
MO	12/3/93	C17070	Tractor trailer	tire	*		none	none	*	*	driver	Driver stated that a tire blew (recap) causing loss of control.
MO	8/19/93	C-14679	Tractor trailer	unknown	*		too fast for conditions	evident	*	*	driver	No defect referred to in the narrative. Inconclusive.
MO	10/16/93	935887	Tractor trailer	unknown	*		none	evident	*	*	driver	No defect referred to in the narrative. Inconclusive.
MO	12/8/93	C-17141	Tractor trailer	unknown	*		violation signal	disablin	*	*	inspector	Vehicle struck rear of second vehicle that had stopped for traffic light. No defect referred to in the narrative. Inconclusive.
MO	8/14/93	931276	Tractor trailer	wheel came off	*		none	none	*	*	driver	Driver stated he felt a vibration in trailer and saw edge of tire coming off in rearview mirror. Right rear trailer wheel and tire broke off.
MO	4/26/93	930579	Tractor trailer	wheel fire	*		none	none	*	*	driver	The left rear inside wheel of the truck caught fire.

Table B14: 1994 Missouri Accident Report Data

State	1994 Date	Report No.	Truck Type	Listed Defect1	Def. 2	Specific Sub-Item	Contributing Circumstance	Injury #1	Injury #2	Injury #3	Driver/ Inspector Opinion	Notes from Narrative
MO	3/7/94	77570	Tractor trailer	brakes	*		drinking, speed	yes	yes	*	driver / inspector	Both driver and passenger of truck stated that the brakes had failed to slow the truck. To avoid intersection driver attempted a turn and rolled the truck. Officer observed one brake hose disconnected from tractor to trailer.
MO	5/24/94	176384	Tractor trailer (two units)	brakes	*		vehicle defect, Too fast for conditions	*	*	*	driver	Driver stated his brakes failed.
MO	5/26/94	94876	Straight truck	brakes	*	broken brake line	vehicle defect	*	*	*	driver	Driver stated his brakes failed. Investigation showed that truck had a broken right front brake line.
MO	5/28/94	26577	Straight truck	brakes	*		vehicle defect	*	*	*	driver	Driver stated his brakes failed and he struck the parked vehicle.
MO	9/6/94	15085	Tractor trailer	brakes	*		vehicle defect, too fast for conditions	yes	*	*	inspector	Inspection of vehicle after accident showed that brakes were out of adjustment. Accident described as vehicle mis-negotiating a tight turn, loosing control of truck.
MO	8/17/94	42315	Tractor trailer	brakes	*		Wrong side (not passing) vehicle defects	*	*	*	driver	Driver stated his brakes failed and he struck other vehicles
MO	9/26/94	141167	Tractor trailer	brakes	*		Too fast, Veh. defects, Following too close	*	*	*	driver	Stated in report that the truck lost had difficulty stopping and that brake failure was Suspected. A detail inspection was conducted but report supplement was not found.
MO	10/4/95	H 1451	Tractor trailer (two units)	coupling	*	*	vehicle defect	*	*	*	Inspector	Pintle hook broke. Resulted in loss of control and accident. Safety chains held.
MO	2/9/94	6435	Tractor trailer	coupling device	*		vehicle defect	yes	*	*	inspector	Investigator stated that a homemade trailer broke free. Safety chains were present.
MO	2/11/94	47322	Tractor trailer	coupling device	*		vehicle defect	*	*	*	driver/ inspector	Driver stated he heard a "loud noise" and that trailer had separated from the truck. Officer found "locking device for the trailer was in the locking position for the trailer was locked and working.
MO	4/4/94	11796	Tractor trailer	coupling device	*		vehicle defect	robabl	*	*	inspector	Vehicle was parked on shoulder partially blocking roadway because trailer had come loose. Was struck in rear.
MO	9/19/94	1607	Tractor trailer	coupling device	*		vehicle defect	*	*	*	Inspector	Inspector stated that trailer came unhooked as truck was pulling out onto road. While attempting to rehook the trailer, truck was struck by another vehicle. Driver stated pin was pulled by mistake.
MO	10/28/94	946480	Trash Truck	engine fire	*		vehicle defect	*	*	*	driver	Driver stated he experienced hydraulic failure. Vehicle caught fire in the engine area.
MO	12/21/94	2244	Tractor trailer	loading & secure	*		vehicle defect	*	*	*	driver	Driver states he heard something pop. Trailer was separated as a result of crash.
MO	6/6/94	5251	Single Unit Truck	loading and secure	*		vehicle defect	*	*	*	driver	Stated in report that debris fell of the bed of truck onto roadway causing collision with vehicle 2.

Table B14: 1994 Missouri Accident Report Data

State	1994 Date	Report No.	Truck Type	Listed Defect1	Def. 2	Specific Sub-Item	Contributing Circumstance	Injury #1	Injury #2	Injury #3	Driver/ Inspector Opinion	Notes from Narrative
MO	8/21/94	27786	Straight truck	parking brake	*		vehicle defect	*	*	*	driver	Driver stated his parking brake failed while he was outside the truck.
MO	12/1/94	104615	Flatbed	parking brake	*		vehicle defect	*	*	*	driver	Driver stated that while out of the truck, the electric micro-brake released. Truck rolled down hill and crashed into telephone pole.
MO	1/29/94	9413610	Single Unit Truck	steering	*		vehicle defect	*	*	*	driver/ inspector	Driver advised that steering went out and that he struck two cars before coming to rest. Driver displayed for the reporting officer that as he turned steering wheel, wheels remained motionless. Verified by officer.
MO	5/11/94	94203	Tractor trailer	steering	*	Tie rod nut missing	vehicle defect	*	*	*	inspector	Driver stated his steering failed. Investigation reveled a missing nut on a tie rod causing it to come loose.
MO	4/22/94	12146	Tractor trailer	tires	*		vehicle defect	yes	*	*	inspector / driver	Inspector stated his right front tire blew out. Swerved and struck another truck.
MO	1/4/94	25130	Flatbed	turn lights	brak e lig hts		vehicle defect	yes	*	*	inspector	Truck turned left while a car was passing it. Car driver stated that no turn signals were used. Inspector verified that both brake and turn signal lights were inoperative on both truck and trailer.
MO	5/4/94	1588	Tractor trailer	unknown	*		vehicle defect	*	*	*	inspector	Stated in report that trailer "ran off right side of roadway, still attached to tractor" Fails to indicate what caused the trailer to float off the road.
MO	11/10/94	0LC01	Tractor trailer	unknown	*		vehicle defect failure to yield	fatal	probable	*	unknown	Report incomplete. No reference to defect in narrative.
MO	4/27/94	e41125	Tractor trailer	wheel fire	*		vehicle defect	*	*	*	inspector	Trailer tandem caught fire. Trailer burned completely.
MO	3/7/94	3404	dumptruck	wheel separation	*		*	*	*	*	inspector	It appeared truck lost its driver side rear set of tires off the rear axle.
MO	4/29/94	942165	Tractor trailer	Wheel separation	*		vehicle defect	*	*	*	inspector	Report states "vehicle was southbound when the left rear driver duels came off struck northbound vehicles #2 and #3."
MO	5/26/94	12982	Tractor trailer (two units)	wheel separation	*		vehicle defect	*	*	*	Inspector	Report states that the left rear wheels on second towed unit came off striking another vehicle.
MO	11/7/94	4385	Tractor trailer	wheel seperation	*		vehicle defect	*	*	*	driver	Report states that two wheels and tires came off of truck which were then struck by oncoming traffic.
MO	11/23/94	8312	Single unit truck	Wheel Seperation	*		vehicle defect	*	*	*	driver	Stated in report that the truck lost its rear right duels which crossed and struck a passenger car. Driver said his brakes and engine quit, then heard a loud noise and saw duels crossing the road beside him.

Table B15: 1993 and 1994 Missouri Data by Specific Defect

	Source	MO				
	Sample Size	754				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Accessories	Gauges (all)	0				0
Accessories	Horn	0				0
Accessories	Hydraulic lift	0				0
Accessories	Other or unknown	0				0
Accessories	Speedometer	0				0
Accessories	Windshield wiper control	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Axle	Adjustable	0				0
Axle	Axle shaft broken	1			1	14,200
Axle	Fell off	0				0
Axle	Multi-speed mechanisms	0				0
Axle	Non-drive	0				0
Axle	Other or unknown	0				0
Sum		**1**	**0**	**0**	**1**	**14,200**
Body	Battery casing	0				0
Body	Cab doors	0				0
Body	Cargo box, van	0				0
Body	Cargo doors, trailer body panels, floor, etc.	0				0
Body	Cargo heater or refrigeration unit	0				0
Body	Cargo tank	0				0
Body	Distance from end of trailer to protection device exceeded.	0				0
Body	Hold-down latch or tilting mechanism	0				0
Body	Interior	0				0
Body	Other or unknown	0				0
Body	Rear load ramp height	0				0
Body	Spare tire rack	0				0
Body	Trailer support (landing gear)	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Brakes	121 brake system	0				0
Brakes	Adjustment	1		1		96,187
Brakes	Air Chambers (Diaphragm)	0				0
Brakes	Air or vacuum booster	0				0
Brakes	Air Valve	0				0
Brakes	Brake linings contaminated	0				0
Brakes	Check valve	0				0
Brakes	Compressor	0				0
Brakes	Couplings (glad hands, etc.)	0				0
Brakes	Cracked lining	0				0
Brakes	Cylinder seal	0				0

Table B15: 1993 and 1994 Missouri Data by Specific Defect

	Source	MO				
	Sample Size	754				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Brakes	Disconnected	0				0
Brakes	Drums	0				0
Brakes	Hydraulic pump or accumulator	0				0
Brakes	Improper installation	0				0
Brakes	Lines	2		1	1	110,387
Brakes	Lining wear	0				0
Brakes	Linings, shoes, fasteners, drum, clevis pin	0				0
Brakes	Low air or vacuum indicator	0				0
Brakes	Master cylinder	0				0
Brakes	Other or unknown	12		2	10	334,374
Brakes	Parking brake	2			2	28,400
Brakes	Pedal, foot valve	0				0
Brakes	Pressure relief valve	0				0
Brakes	Springs, cams, adjusters, actuator valve	0				0
Brakes	Wheel cylinder	0				0
Sum		**17**	**0**	**4**	**13**	**569,348**
Cooling system	Belt water pump	0				0
Cooling system	Hoses, clamps, cap, thermostat, shutters	0				0
Cooling system	Other or unknown	0				0
Cooling system	Radiator	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Coupling	Breakaway device	0				0
Coupling	Fifth wheel	0				0
Coupling	Fifth wheel kingpin	0				0
Coupling	Fifth wheel plate	0				0
Coupling	Locking and Release mechanism	0				0
Coupling	Mounting, welds, u-bolts	0				0
Coupling	Not properly engaged	0				0
Coupling	Other or unknown	7		2	5	263,374
Coupling	Pintle Hook	1			1	14,200
Coupling	Saddle mount	0				0
Coupling	Spindle broken	1		1		96,187
Coupling	Tow bar, ball & socket, etc.	0				0
Sum		**9**	**0**	**3**	**6**	**373,761**
Driveline	Carrier bearings	0				0
Driveline	Differential failure	0				0
Driveline	Fell out (part or all)	0				0
Driveline	Other or unknown	0				0
Driveline	Shaft broke	0				0
Driveline	Universal joints	0				0

Table B15: 1993 and 1994 Missouri Data by Specific Defect

	Source	MO				
	Sample Size	754				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Sum		**0**	**0**	**0**	**0**	**0**
Electrical	Battery, cables	0				0
Electrical	Fuses, circuit breakers	0				0
Electrical	Generator, alternator, voltage regulator	0				0
Electrical	Ingnition system	0				0
Electrical	Instruments, controls	0				0
Electrical	Lights, brake	0				0
Electrical	Lights, head	1			1	14,200
Electrical	Lights, other	0				0
Electrical	Lights, reverse	0				0
Electrical	Lights, tail	0				0
Electrical	Lights, turn and hazard	1		1		96,187
Electrical	Other or unknown	0				0
Electrical	Wiring (Cargo area)	0				0
Electrical	Wiring (power unit)	0				0
Sum		**2**	**0**	**1**	**1**	**110,387**
Engine	Air blower	0				0
Engine	Crankshaft, internals	0				0
Engine	Flywheel, vib. dampener	0				0
Engine	Oil pump, lube system	0				0
Engine	Other or Unknown	1			1	14,200
Engine	Timing gear	0				0
Engine	Valve train	0				0
Sum		**1**	**0**	**0**	**1**	**14,200**
Exhaust	Exhaust pipe, hangers	0				0
Exhaust	Other or unknown	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Frame	Cross members	0				0
Frame	Other or Unknown	0				0
Frame	Rails and reinforcement	0				0
Frame	Rivets, bolts, welds	0				0
Frame	Stabilizer Bars	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Fuel System	Carburetor	0				0
Fuel System	Fuel filters	0				0
Fuel System	Fuel lines, valves	0				0
Fuel System	Fuel pump	0				0
Fuel System	Fuel tank	0				0
Fuel System	Injection pump	0				0
Fuel System	Other or unknown	0				0
Fuel System	Throttle linkage	1			1	14,200
Sum		**1**	**0**	**0**	**1**	**14,200**
Load Securement	Baffles (cargo tank)	0				0
Load Securement	Battery casing fell off	0				0
Load Securement	Bolts holding tank failed	0				0
Load Securement	Bracing (metal rolls)	0				0
Load Securement	Other or Unknown	3		1	2	124,587

Table B15: 1993 and 1994 Missouri Data by Specific Defect

	Source	MO				
	Sample Size	754				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Load Securement	Part of load fell out	1			1	14,200
Load Securement	Tie downs, chains, etc.	0				0
Sum		**4**	**0**	**1**	**3**	**138,787**
Other or Unknown		5	1	3	1	3,856,700
Sum		**5**	**1**	**3**	**1**	**3,856,700**
Steering	Ball & socket	0				0
Steering	Disconnected from box	0				0
Steering	gear	0				0
Steering	linkage, drag link, tie rod	0				0
Steering	Other or unknown	1			1	14,200
Steering	power steering system	0				0
Steering	Steering box loose	0				0
Steering	Steering wheel, column shaft	0				0
Steering	Tie rod (loose)	1			1	14,200
Sum		2	0	0	2	28,400
Suspension	Air bags, controls, piping	0				0
Suspension	Arms, torque, rods, walking beams	0				0
Suspension	Bushings, pivots, bearings	0				0
Suspension	Other or unknown	0				0
Suspension	Shackle, pin, hanger	0				0
Suspension	Shocks and mountings	0				0
Suspension	Spring	0				0
Suspension	Torsion bars, stabilizer, mountings	0				0
Suspension	U-bolts holding spring	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Tires	Blowout	3		1	2	124,587
Tires	Low pressure	0				0
Tires	Original tread	0				0
Tires	Other or unknown	0				0
Tires	Overloaded	0				0
Tires	Recap or retread	0				0
Tires	Sidewall separation	0				0
Tires	Tread, worn	0				0
Tires	Tread separation	0				0
Tires	Tube, or tube valve	0				0
Sum		**3**	**0**	**1**	**2**	**124,587**
Transmission	All auxiliary failures	0				0
Transmission	Automatic tran. internal	0				0
Transmission	Clutch	0				0
Transmission	Clutch linkage	0				0
Transmission	Manual tran. internal	0				0
Transmission	Other or Unknown	0				0

Table B15: 1993 and 1994 Missouri Data by Specific Defect

	Source	MO				
	Sample Size	754				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Transmission	Shift controls & linkage	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Wheels	Leaking grease	0				0
Wheels	Other of Unknown	8			8	113,600
Wheels	Rims, flange, ring, hub, fasteners	0				0
Wheels	Studs, lugs, fasteners	0				0
Wheels	Wheel bearings	0				0
Wheels	Wheel hubs	0				0
Wheels	Wheel spacer	0				0
Sum		**8**	**0**	**0**	**8**	**113,600**
Totals		**53**	**1**	**13**	**39**	**5,358,170**

B16: 1993 Missouri Data by Defect Category

Sample Size 376

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle	1	0.27%			1	14,200
Back Up Lights		0.00%				0
Brake Lights		0.00%				0
Brakes	8	2.13%		2	6	277,574
Coupling	4	1.06%		1	3	138,787
Debris Falling Off		0.00%				0
Driveshaft		0.00%				0
Dump Activator		0.00%				0
Frame		0.00%				0
Motor Fire		0.00%				0
Other		0.00%				0
Springs		0.00%				0
Steering		0.00%				0
Suspension		0.00%				0
Throttle Sticking	1	0.27%			1	14,200
Tie Rod		0.00%				0
Loading & Securement	2	0.53%		1	1	110,387
Tire	2	0.53%			2	28,400
Trailer Door		0.00%				0
Trailer Fire		0.00%				0
Turn Lights		0.00%				0
Unknown	3	0.80%		3		288,561
Wheel Bearing		0.00%				0
Wheel Fire	1	0.27%			1	14,200
Wheel Separation	1	0.27%			1	14,200
Head Lights	1	0.27%			1	14,200
Parking Brake		0.00%				0
Tail Lights		0.00%				0
Transmission		0.00%				0
Electrical		0.00%				0
TOTALS	**24**	**6.38%**	**0**	**7**	**17**	**914,709**

Other:

Unknown: Defect not specified in narrative or check boxes.

B17: 1994 Missouri Data by Defect Category

Sample Size 378

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle		0.00%				0
Back Up Lights		0.00%				0
Brake Lights		0.00%				0
Brakes	7	1.85%		2	5	263,374
Coupling	5	1.32%		2	3	234,974
Debris Falling Off		0.00%				0
Driveshaft		0.00%				0
Dump Activator		0.00%				0
Frame		0.00%				0
Motor Fire	1	0.26%			1	14,200
Other		0.00%				0
Springs		0.00%				0
Steering	2	0.53%			2	28,400
Suspension		0.00%				0
Throttle Sticking		0.00%				0
Tie Rod		0.00%				0
Loading & Securement	2	0.53%			2	28,400
Tire	1	0.26%		1		96,187
Trailer Door		0.00%				0
Trailer Fire		0.00%				0
Turn Lights	1	0.26%		1		96,187
Unknown	2	0.53%	1		1	3,568,139
Wheel Bearing		0.00%				0
Wheel Fire	1	0.26%			1	14,200
Wheel Separation	5	1.32%			5	71,000
Head Lights		0.00%				0
Parking Brake	2	0.53%			2	28,400
Tail Lights		0.00%				0
Transmission		0.00%				0
Electrical		0.00%				0
TOTALS	**29**	**7.67%**	**1**	**6**	**22**	**4,443,461**

Other:

Unknown: Not specified in report

B18: 1993 and 1994 Missouri Data by Defect Category

Sample Size 754

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle	1	0.13%	0	0	1	14,200
Back Up Lights	0	0.00%	0	0	0	0
Brake Lights	0	0.00%	0	0	0	0
Brakes	15	1.99%	0	4	11	540,948
Coupling	9	1.19%	0	3	6	373,761
Debris Falling Off	0	0.00%	0	0	0	0
Driveshaft	0	0.00%	0	0	0	0
Dump Activator	0	0.00%	0	0	0	0
Frame	0	0.00%	0	0	0	0
Motor Fire	1	0.13%	0	0	1	14,200
Other	0	0.00%	0	0	0	0
Springs	0	0.00%	0	0	0	0
Steering	2	0.27%	0	0	2	28,400
Suspension	0	0.00%	0	0	0	0
Throttle Sticking	1	0.13%	0	0	1	14,200
Tie Rod	0	0.00%	0	0	0	0
Loading & Securement	4	0.53%	0	1	3	138,787
Tire	3	0.40%	0	1	2	124,587
Trailer Door	0	0.00%	0	0	0	0
Trailer Fire	0	0.00%	0	0	0	0
Turn Lights	1	0.13%	0	1	0	96,187
Unknown	5	0.66%	1	3	1	3,856,700
Wheel Bearing	0	0.00%	0	0	0	0
Wheel Fire	2	0.27%	0	0	2	28,400
Wheel Separation	6	0.80%	0	0	6	85,200
Head Lights	1	0.13%	0	0	1	14,200
Parking Brake	2	0.27%	0	0	2	28,400
Tail Lights	0	0.00%	0	0	0	0
Transmission	0	0.00%	0	0	0	0
Electrical	0	0.00%	0	0	0	0
TOTALS	**53**	**7.03%**	**1**	**13**	**39**	**5,358,170**

Other:

Unknown:

APPENDIX B4

Washington Database

Appendix B4 contains CMV accident data from the state of Washington. Tables B19 and B20 contain the data collected from the accident reports indicating a mechanical defect as a contributing factor. Table B21 groups the accident data into specific defect categories. Tables B22, B23, and B24 sum the accident data into broad categories and give occurrences, proportions, and costs for each of the broad categories.

Table B19: 1993 Washington Accident Report Data

State	1993 Date	Report No.	Truck Type	Listed Defect1	Defect 2	Specific Sub-Item	Contributing Circumstance	Injury #1	Inj #2	Inj #3	Driver/ Inspector Opinion	Notes from Narrative
WA	6/4/93	221766	tractor trailer	brakes	*		Defective brakes	non disable (evident)	*	*	driver/ inspector	Lost control in heavy rain. Defective brakes and could not stop
WA	10/9/93	380778	Dump	brakes	*		Operating defective equipment	*	*	*	driver	Driver said brakes went to floor. Failed to stop.
WA	9/14/93	351376	tractor trailer	brakes	*		Operating defective equipment	*	*	*	driver/ inspector	Trailer fishtailed and spun combination 180, due to inoperative trailer brakes
WA	5/16/93	181530	tractor trailer	brakes	*		Defective brakes	*	*	*	driver/ inspector	Brake line to trailer dislodged, causing brakes to lock up. Truck jacknifed.
WA	4/14/93	122447	Flatbed	Debris	*		Other defects	*	*	*	N/A	Battery casing came off, other vehicles ran it over
WA	8/5/93	292740	tractor trailer	load & secure	*		inproper tie-down	*	*	*	N/A	Bails of hey fell off truck while turning
WA	10/7/93	371792	2 axle commercial van	throttle	*		Operating defective equipment	possible	*	*	driver/ inspector	Throttle stuck open. Brakes failed to stop vehicle.

Table B20: 1994 Washington Accident Report Data

State	1994 Date	Report No.	Truck Type	Listed Defect1	Defect 2	Specific Sub-Item	Contributing Circumstance	Injury #1	Inj #2	Inj #3	Driver/ Inspector Opinion	Notes from Narrative
WA	2/4/94	40350	tractor trailer	brakes	*		operating defective equip.	*	*	*	*	Brakes went out completely
WA	7/1/94	252179	tractor trailer	brakes	*		operating defective equip.	*	*	*	driver	Driver stated that brakes went out
WA	9/7/94	341569	dumptruck	brakes	*		speed/def. equip	possible	*	*	*	Driver stated partial brakes only, fluid leaking on brake pedal
WA	7/12/94	320403	flatbed	brakes	*		*	yes	*	*	driver	Brakes failed according to driver in passenger car that was rear-ended by truck
WA	8/12/94	310617	tractor trailer	brakes	*		speed/following too close	possible	*	*	*	Nothing in the narrative about defective brakes, just brief description of accident
WA	6/25/94	250198	tractor trailer	frame	*		operating defective equip.	*	*	*	inspector	Excavator fell off trailer. Possible cause stated as broken frame rail on trailer.
WA	11/15/94	442425	flatbed	load & secure	*	*	none	fatal	*	*	N/A	Rotary cutter not tied down to bed. Fell off around curve and hit car.
WA	5/594	152541	tractor trailer	load & secure	*		none	*	*	*	*	Tie-down holding backhoe broke, causing trailer to sway and break safety chins and hook
WA	12/15/94	530196	truck w/ boom	other	*		other	*	*	*	*	Truck had a boom that wouldn't go down all the way. Hit overpass.
WA	6/1/94	200485	dumptruck	spring	*		none	*	*	*	*	Spring broke on trailer, causing trailer to overturn
WA	6/6/94	211975	tractor	steering	*		other (steering)	possible	*	*	inspector	Driver stated he lost steering control. Inspector stated that vehicle steering column was defective at the steering box
WA	7/14/94	271585	semi, w/ 2 trailers	tire	coupling device		def. equip.	*	*	*	inspector	Tire blew to start accident. "Safety chains fail to hold trailer."Clearly states defective eye bolts, citation issued for defective equipment.
WA	9/30/94	431307	tractor trailer	tire	*		*	*	*	*	*	Left rear tire blew on trailer

Table B21: 1993 and 1994 Washington Data by Specific Defect

	Source	WA				
	Sample Size	395				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Accessories	Gauges (all)	0				0
Accessories	Horn	0				0
Accessories	Hydraulic lift	0				0
Accessories	Other or unknown	0				0
Accessories	Speedometer	0				0
Accessories	Windshield wiper control	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Axle	Adjustable	0				0
Axle	Axle shaft broken	0				0
Axle	Fell off	0				0
Axle	Multi-speed mechanisms	0				0
Axle	Non-drive	0				0
Axle	Other or unknown	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Body	Battery casing	1			1	14,200
Body	Cab doors	0				0
Body	Cargo box, van	0				0
Body	Cargo doors, trailer body panels, floor, etc.	0				0
Body	Cargo heater or refrigeration unit	0				0
Body	Cargo tank	0				0
Body	Distance from end of trailer to protection device exceeded.	0				0
Body	Hold-down latch or tilting mechanism	0				0
Body	Interior	0				0
Body	Other or unknown	0				0
Body	Rear load ramp height	0				0
Body	Spare tire rack	0				0
Body	Trailer support (landing gear)	0				0
Sum		**1**	**0**	**0**	**1**	**14,200**
Brakes	121 brake system	0				0
Brakes	Adjustment	0				0
Brakes	Air Chambers (Diaphragm)	0				0
Brakes	Air or vacuum booster	0				0
Brakes	Air Valve	0				0
Brakes	Brake linings contaminated	0				0
Brakes	Check valve	0				0
Brakes	Compressor	0				0
Brakes	Couplings (glad hands, etc.)	0				0
Brakes	Cracked lining	0				0
Brakes	Cylinder seal	0				0

Table B21: 1993 and 1994 Washington Data by Specific Defect

	Source	WA				
	Sample Size	395				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Brakes	Disconnected	0				0
Brakes	Drums	0				0
Brakes	Hydraulic pump or accumulator	0				0
Brakes	Improper installation	0				0
Brakes	Lines	1			1	14,200
Brakes	Lining wear	0				0
Brakes	Linings, shoes, fasteners, drum, clevis pin	0				0
Brakes	Low air or vacuum indicator	0				0
Brakes	Master cylinder	0				0
Brakes	Other or unknown	8		4	4	441,548
Brakes	Parking brake	0				0
Brakes	Pedal, foot valve	0				0
Brakes	Pressure relief valve	0				0
Brakes	Springs, cams, adjusters, actuator valve	0				0
Brakes	Wheel cylinder	0				0
Sum		**9**	**0**	**4**	**5**	**455,748**
Cooling system	Belt water pump	0				0
Cooling system	Hoses, clamps, cap, thermostat, shutters	0				0
Cooling system	Other or unknown	0				0
Cooling system	Radiator	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Coupling	Breakaway device	0				0
Coupling	Fifth wheel	0				0
Coupling	Fifth wheel kingpin	0				0
Coupling	Fifth wheel plate	0				0
Coupling	Locking and Release mechanism	0				0
Coupling	Mounting, welds, u-bolts	0				0
Coupling	Not properly engaged	0				0
Coupling	Other or unknown	0				0
Coupling	Pintle Hook	0				0
Coupling	Saddle mount	0				0
Coupling	Spindle broken	0				0
Coupling	Tow bar, ball & socket, etc.	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Driveline	Carrier bearings	0				0
Driveline	Differential failure	0				0
Driveline	Fell out (part or all)	0				0
Driveline	Other or unknown	0				0
Driveline	Shaft broke	0				0
Driveline	Universal joints	0				0

Table B21: 1993 and 1994 Washington Data by Specific Defect

	Source	WA				
	Sample Size	395				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Sum		**0**	**0**	**0**	**0**	**0**
Electrical	Battery, cables	0				0
Electrical	Fuses, circuit breakers	0				0
Electrical	Generator, alternator, voltage regulator	0				0
Electrical	Ingnition system	0				0
Electrical	Instruments, controls	0				0
Electrical	Lights, brake	0				0
Electrical	Lights, head	0				0
Electrical	Lights, other	0				0
Electrical	Lights, reverse	0				0
Electrical	Lights, tail	0				0
Electrical	Lights, turn and hazard	0				0
Electrical	Other or unknown	0				0
Electrical	Wiring (Cargo area)	0				0
Electrical	Wiring (power unit)	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Engine	Air blower	0				0
Engine	Crankshaft, internals	0				0
Engine	Flywheel, vib. dampener	0				0
Engine	Oil pump, lube system	0				0
Engine	Other or Unknown	0				0
Engine	Timing gear	0				0
Engine	Valve train	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Exhaust	Exhaust pipe, hangers	0				0
Exhaust	Other or unknown	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Frame	Cross members	0				0
Frame	Other or Unknown	0				0
Frame	Rails and reinforcement	1			1	14,200
Frame	Rivets, bolts, welds	0				0
Frame	Stabilizer Bars	0				0
Sum		**1**	**0**	**0**	**1**	**14,200**
Fuel System	Carburetor	0				0
Fuel System	Fuel filters	0				0
Fuel System	Fuel lines, valves	0				0
Fuel System	Fuel pump	0				0
Fuel System	Fuel tank	0				0
Fuel System	Injection pump	0				0
Fuel System	Other or unknown	0				0
Fuel System	Throttle linkage	1		1		96,187
Sum		**1**	**0**	**1**	**0**	**96,187**
Load Securement	Baffles (cargo tank)	0				0
Load Securement	Battery casing fell off	0				0
Load Securement	Bolts holding tank failed	0				0
Load Securement	Bracing (metal rolls)	0				0
Load Securement	Other or Unknown	0				0

Table B21: 1993 and 1994 Washington Data by Specific Defect

	Source	WA				
	Sample Size	395				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Load Securement	Part of load fell out	2	1		1	3,568,139
Load Securement	Tie downs, chains, etc.	1			1	14,200
Sum		**3**	**1**	**0**	**2**	**3,582,339**
Other or Unknown		1			1	14,200
Sum		**1**	**0**	**0**	**1**	**14,200**
Steering	Ball & socket	0				0
Steering	Disconnected from box	0				0
Steering	gear	0				0
Steering	linkage, drag link, tie rod	0				0
Steering	Other or unknown	0				0
Steering	power steering system	0				0
Steering	Steering box loose	0				0
Steering	Steering wheel, column shaft	0				0
Steering	Tie rod (loose)	0				0
Sum		0	0	0	0	0
Suspension	Air bags, controls, piping	0				0
Suspension	Arms, torque, rods, walking beams	0				0
Suspension	Bushings, pivots, bearings	0				0
Suspension	Other or unknown	1		1		96,187
Suspension	Shackle, pin, hanger	0				0
Suspension	Shocks and mountings	0				0
Suspension	Spring	1			1	14,200
Suspension	Torsion bars, stabilizer, mountings	0				0
Suspension	U-bolts holding spring	0				0
Sum		**2**	**0**	**1**	**1**	**110,387**
Tires	Blowout	2			2	28,400
Tires	Low pressure	0				0
Tires	Original tread	0				0
Tires	Other or unknown	0				0
Tires	Overloaded	0				0
Tires	Recap or retread	0				0
Tires	Sidewall separation	0				0
Tires	Tread, worn	0				0
Tires	Tread separation	0				0
Tires	Tube, or tube valve	0				0
Sum		**2**	**0**	**0**	**2**	**28,400**
Transmission	All auxiliary failures	0				0
Transmission	Automatic tran. internal	0				0
Transmission	Clutch	0				0
Transmission	Clutch linkage	0				0
Transmission	Manual tran. internal	0				0
Transmission	Other or Unknown	0				0

Table B21: 1993 and 1994 Washington Data by Specific Defect

	Source	WA				
	Sample Size	395				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Transmission	Shift controls & linkage	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Wheels	Leaking grease	0				0
Wheels	Other of Unknown	0				0
Wheels	Rims, flange, ring, hub, fasteners	0				0
Wheels	Studs, lugs, fasteners	0				0
Wheels	Wheel bearings	0				0
Wheels	Wheel hubs	0				0
Wheels	Wheel spacer	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Totals		**20**	**1**	**6**	**13**	**4,315,661**

B22: 1993 Washington Data by Defect Category

Sample Size 206

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle		0.00%				0
Back Up Lights		0.00%				0
Brake Lights		0.00%				0
Brakes	4	1.94%		1	3	138,787
Coupling		0.00%				0
Debris Falling Off	1	0.49%			1	14,200
Driveshaft		0.00%				0
Dump Activator		0.00%				0
Frame		0.00%				0
Motor Fire		0.00%				0
Other		0.00%				0
Springs		0.00%				0
Steering		0.00%				0
Suspension		0.00%				0
Throttle Sticking	1	0.49%		1		96,187
Tie Rod		0.00%				0
Loading & Securement	1	0.49%			1	14,200
Tire		0.00%				0
Trailer Door		0.00%				0
Trailer Fire		0.00%				0
Turn Lights		0.00%				0
Unknown		0.00%				0
Wheel Bearing		0.00%				0
Wheel Fire		0.00%				0
Wheel Separation		0.00%				0
Head Lights		0.00%				0
Parking Brake		0.00%				0
Tail Lights		0.00%				0
Transmission		0.00%				0
Electrical		0.00%				0
TOTALS	**7**	**3.40%**	**0**	**2**	**5**	**263,374**

Other:

Unknown:

Debris falling off: Battery casing fell off. Hit by other vehicles.

B23: 1994 Washington Data by Defect Category

Sample Size 189

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle		0.00%				0
Back Up Lights		0.00%				0
Brake Lights		0.00%				0
Brakes	5	2.65%		3	2	316,961
Coupling		0.00%				0
Debris Falling Off		0.00%				0
Driveshaft		0.00%				0
Dump Activator		0.00%				0
Frame	1	0.53%			1	14,200
Motor Fire		0.00%				0
Other	1	0.53%			1	14,200
Springs	1	0.53%			1	14,200
Steering	1	0.53%		1		96,187
Suspension		0.00%				0
Throttle Sticking		0.00%				0
Tie Rod		0.00%				0
Loading & Securement	2	1.06%	1		1	3,568,139
Tire	2	1.06%			2	28,400
Trailer Door		0.00%				0
Trailer Fire		0.00%				0
Turn Lights		0.00%				0
Unknown		0.00%				0
Wheel Bearing		0.00%				0
Wheel Fire		0.00%				0
Wheel Separation		0.00%				0
Head Lights		0.00%				0
Parking Brake		0.00%				0
Tail Lights		0.00%				0
Transmission		0.00%				0
Electrical		0.00%				0
TOTALS	**13**	**6.88%**	**1**	**4**	**8**	**4,052,287**

Other: Boom in trailer would not lower. Hit overpass.

Unknown:

B24: 1993 and 1994 Washington Data by Defect Category

Sample Size 395

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle	0	0.00%	0	0	0	0
Back Up Lights	0	0.00%	0	0	0	0
Brake Lights	0	0.00%	0	0	0	0
Brakes	9	2.28%	0	4	5	455,748
Coupling	0	0.00%	0	0	0	0
Debris Falling Off	1	0.25%	0	0	1	14,200
Driveshaft	0	0.00%	0	0	0	0
Dump Activator	0	0.00%	0	0	0	0
Frame	1	0.25%	0	0	1	14,200
Motor Fire	0	0.00%	0	0	0	0
Other	1	0.25%	0	0	1	14,200
Springs	1	0.25%	0	0	1	14,200
Steering	1	0.25%	0	1	0	96,187
Suspension	0	0.00%	0	0	0	0
Throttle Sticking	1	0.25%	0	1	0	96,187
Tie Rod	0	0.00%	0	0	0	0
Loading & Securement	3	0.76%	1	0	2	3,582,339
Tire	2	0.51%	0	0	2	28,400
Trailer Door	0	0.00%	0	0	0	0
Trailer Fire	0	0.00%	0	0	0	0
Turn Lights	0	0.00%	0	0	0	0
Unknown	0	0.00%	0	0	0	0
Wheel Bearing	0	0.00%	0	0	0	0
Wheel Fire	0	0.00%	0	0	0	0
Wheel Separation	0	0.00%	0	0	0	0
Head Lights	0	0.00%	0	0	0	0
Parking Brake	0	0.00%	0	0	0	0
Tail Lights	0	0.00%	0	0	0	0
Transmission	0	0.00%	0	0	0	0
Electrical	0	0.00%	0	0	0	0
TOTALS	**20**	**5.06%**	**1**	**6**	**13**	**4,315,661**

APPENDIX B5

Idaho Database

Appendix B5 contains CMV accident data from the state of Idaho. Tables B25 and B26 contain the data collected from the accident reports indicating a mechanical defect as a contributing factor. Table B27 groups the accident data into specific defect categories. Tables B28, B29, and B30 sum the accident data into broad categories and give occurrences, proportions, and costs for each of the broad categories.

Table B25: 1993 Idaho Accident Report Data

State	1993 Date	Report No.	Truck Type	Listed Defect1	Defect 2	Defect 3	Contributing Circumstance	Injury Severity	Injury #2	Injury #3	Driver/ Inspector Opinion	Notes from Narrative
ID	8/13/93	932450132		brakes	*	*	Veh. defect	yes	*	*		
ID	9/9/93	932590058	tractor trailer	brakes	*	*	Veh. defect	yes	yes	*	Driver	Driver stated lost brakes. Released and tried again. Blew horn for warning.
ID	8/20/93	932650023	tractor trailer	other	*	*	Veh. defect	*	*	*	Driver / Inspector	Log truck. "rench on tenilse broke. Caused truck to overturn."
ID	8/27/93	932970008	tractor trailer	tie down	*	*	Veh. defect	*	*	*	Inspector	Load shifted (cattle). Caused tie down to brake. Bed tilted. Truck overturned.
ID	10/28/93	933310002	tractor trailer	tire	*	*	Veh. defect	yes	*	*	driver	Tire blew. Lost traction.

Table B26: 1994 Idaho Accident Report Data

State	1994 Date	Report No.	Truck Type	Listed Defect1	Defect 2	Defect 3	Contributing Circumstance	Injury Severity	Injury #2	Injury #3	Driver/ Inspector Opinion	Notes from Narrative
ID	11/9/94	94370015	tractor trailer	unknown	*	*	Mech. Defect	*	*	*	?	No narrative
ID	5/6/94	94146006	Dump	brakes	*	*	Mech. Defect	*	*	*	Inspector	Rear end accident. No narrative.

Table B27: 1993 and 1994 Idaho Data by Specific Defect

	Source	ID				
	Sample Size	142				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Accessories	Gauges (all)	0				0
Accessories	Horn	0				0
Accessories	Hydraulic lift	0				0
Accessories	Other or unknown	0				0
Accessories	Speedometer	0				0
Accessories	Windshield wiper control	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Axle	Adjustable	0				0
Axle	Axle shaft broken	0				0
Axle	Fell off	0				0
Axle	Multi-speed mechanisms	0				0
Axle	Non-drive	0				0
Axle	Other or unknown	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Body	Battery casing	0				0
Body	Cab doors	0				0
Body	Cargo box, van	0				0
Body	Cargo doors, trailer body panels, floor, etc.	0				0
Body	Cargo heater or refrigeration unit	0				0
Body	Cargo tank	0				0
Body	Distance from end of trailer to protection device exceeded.	0				0
Body	Hold-down latch or tilting mechanism	0				0
Body	Interior	0				0
Body	Other or unknown	0				0
Body	Rear load ramp height	0				0
Body	Spare tire rack	0				0
Body	Trailer support (landing gear)	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Brakes	121 brake system	0				0
Brakes	Adjustment	0				0
Brakes	Air Chambers (Diaphragm)	0				0
Brakes	Air or vacuum booster	0				0
Brakes	Air Valve	0				0
Brakes	Brake linings contaminated	0				0
Brakes	Check valve	0				0
Brakes	Compressor	0				0
Brakes	Couplings (glad hands, etc.)	0				0
Brakes	Cracked lining	0				0
Brakes	Cylinder seal	0				0

Table B27: 1993 and 1994 Idaho Data by Specific Defect

	Source	ID				
	Sample Size	142				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Brakes	Disconnected	0				0
Brakes	Drums	0				0
Brakes	Hydraulic pump or accumulator	0				0
Brakes	Improper installation	0				0
Brakes	Lines	0				0
Brakes	Lining wear	0				0
Brakes	Linings, shoes, fasteners, drum, clevis pin	0				0
Brakes	Low air or vacuum indicator	0				0
Brakes	Master cylinder	0				0
Brakes	Other or unknown	3		2	1	206,574
Brakes	Parking brake	0				0
Brakes	Pedal, foot valve	0				0
Brakes	Pressure relief valve	0				0
Brakes	Springs, cams, adjusters, actuator valve	0				0
Brakes	Wheel cylinder	0				0
Sum		**3**	**0**	**2**	**1**	**206,574**
Cooling system	Belt water pump	0				0
Cooling system	Hoses, clamps, cap, thermostat, shutters	0				0
Cooling system	Other or unknown	0				0
Cooling system	Radiator	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Coupling	Breakaway device	0				0
Coupling	Fifth wheel	0				0
Coupling	Fifth wheel kingpin	0				0
Coupling	Fifth wheel plate	0				0
Coupling	Locking and Release mechanism	0				0
Coupling	Mounting, welds, u-bolts	0				0
Coupling	Not properly engaged	0				0
Coupling	Other or unknown	0				0
Coupling	Pintle Hook	0				0
Coupling	Saddle mount	0				0
Coupling	Spindle broken	0				0
Coupling	Tow bar, ball & socket, etc.	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Driveline	Carrier bearings	0				0
Driveline	Differential failure	0				0
Driveline	Fell out (part or all)	0				0
Driveline	Other or unknown	0				0
Driveline	Shaft broke	0				0
Driveline	Universal joints	0				0

Table B27: 1993 and 1994 Idaho Data by Specific Defect

	Source	ID				
	Sample Size	142				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Sum		**0**	**0**	**0**	**0**	**0**
Electrical	Battery, cables	0				0
Electrical	Fuses, circuit breakers	0				0
Electrical	Generator, alternator, voltage regulator	0				0
Electrical	Ingnition system	0				0
Electrical	Instruments, controls	0				0
Electrical	Lights, brake	0				0
Electrical	Lights, head	0				0
Electrical	Lights, other	0				0
Electrical	Lights, reverse	0				0
Electrical	Lights, tail	0				0
Electrical	Lights, turn and hazard	0				0
Electrical	Other or unknown	0				0
Electrical	Wiring (Cargo area)	0				0
Electrical	Wiring (power unit)	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Engine	Air blower	0				0
Engine	Crankshaft, internals	0				0
Engine	Flywheel, vib. dampener	0				0
Engine	Oil pump, lube system	0				0
Engine	Other or Unknown	0				0
Engine	Timing gear	0				0
Engine	Valve train	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Exhaust	Exhaust pipe, hangers	0				0
Exhaust	Other or unknown	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Frame	Cross members	0				0
Frame	Other or Unknown	0				0
Frame	Rails and reinforcement	0				0
Frame	Rivets, bolts, welds	0				0
Frame	Stabilizer Bars	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Fuel System	Carburetor	0				0
Fuel System	Fuel filters	0				0
Fuel System	Fuel lines, valves	0				0
Fuel System	Fuel pump	0				0
Fuel System	Fuel tank	0				0
Fuel System	Injection pump	0				0
Fuel System	Other or unknown	0				0
Fuel System	Throttle linkage	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Load Securement	Baffles (cargo tank)	0				0
Load Securement	Battery casing fell off	0				0
Load Securement	Bolts holding tank failed	0				0
Load Securement	Bracing (metal rolls)	0				0
Load Securement	Other or Unknown	0				0

Table B27: 1993 and 1994 Idaho Data by Specific Defect

	Source	ID				
	Sample Size	142				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Load Securement	Part of load fell out	0				0
Load Securement	Tie downs, chains, etc.	1			1	14,200
Sum		**1**	**0**	**0**	**1**	**14,200**
Other or Unknown		2			2	28,400
Sum		**2**	**0**	**0**	**2**	**28,400**
Steering	Ball & socket	0				0
Steering	Disconnected from box	0				0
Steering	gear	0				0
Steering	linkage, drag link, tie rod	0				0
Steering	Other or unknown	0				0
Steering	power steering system	0				0
Steering	Steering box loose	0				0
Steering	Steering wheel, column shaft	0				0
Steering	Tie rod (loose)	0				0
Sum		0	0	0	0	0
Suspension	Air bags, controls, piping	0				0
Suspension	Arms, torque, rods, walking beams	0				0
Suspension	Bushings, pivots, bearings	0				0
Suspension	Other or unknown	0				0
Suspension	Shackle, pin, hanger	0				0
Suspension	Shocks and mountings	0				0
Suspension	Spring	0				0
Suspension	Torsion bars, stabilizer, mountings	0				0
Suspension	U-bolts holding spring	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Tires	Blowout	1		1		96,187
Tires	Low pressure	0				0
Tires	Original tread	0				0
Tires	Other or unknown	0				0
Tires	Overloaded	0				0
Tires	Recap or retread	0				0
Tires	Sidewall separation	0				0
Tires	Tread, worn	0				0
Tires	Tread separation	0				0
Tires	Tube, or tube valve	0				0
Sum		**1**	**0**	**1**	**0**	**96,187**
Transmission	All auxiliary failures	0				0
Transmission	Automatic tran. internal	0				0
Transmission	Clutch	0				0
Transmission	Clutch linkage	0				0
Transmission	Manual tran. internal	0				0
Transmission	Other or Unknown	0				0

Table B27: 1993 and 1994 Idaho Data by Specific Defect

	Source	ID				
	Sample Size	142				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Transmission	Shift controls & linkage	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Wheels	Leaking grease	0				0
Wheels	Other of Unknown	0				0
Wheels	Rims, flange, ring, hub, fasteners	0				0
Wheels	Studs, lugs, fasteners	0				0
Wheels	Wheel bearings	0				0
Wheels	Wheel hubs	0				0
Wheels	Wheel spacer	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Totals		**7**	**0**	**3**	**4**	**345,361**

B28: 1993 Idaho Data by Defect Category

Sample Size 73

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle		0.00%				0
Back Up Lights		0.00%				0
Brake Lights		0.00%				0
Brakes	2	2.74%		2		192,374
Coupling		0.00%				0
Debris Falling Off		0.00%				0
Driveshaft		0.00%				0
Dump Activator		0.00%				0
Frame		0.00%				0
Motor Fire		0.00%				0
Other	1	1.37%			1	14,200
Springs		0.00%				0
Steering		0.00%				0
Suspension		0.00%				0
Throttle Sticking		0.00%				0
Tie Rod		0.00%				0
Loading & Securement	1	1.37%			1	14,200
Tire	1	1.37%		1		96,187
Trailer Door		0.00%				0
Trailer Fire		0.00%				0
Turn Lights		0.00%				0
Unknown		0.00%				0
Wheel Bearing		0.00%				0
Wheel Fire		0.00%				0
Wheel Separation		0.00%				0
Head Lights		0.00%				0
Parking Brake		0.00%				0
Tail Lights		0.00%				0
Transmission		0.00%				0
Electrical		0.00%				0
TOTALS	**5**	**6.85%**	**0**	**3**	**2**	**316,961**

Other: "Rench on tenilse broke. Caused truck to overturn."

B29: 1994 Idaho Data by Defect Category

Sample Size 69

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle		0.00%				0
Back Up Lights		0.00%				0
Brake Lights		0.00%				0
Brakes	1	1.45%			1	14,200
Coupling		0.00%				0
Debris Falling Off		0.00%				0
Driveshaft		0.00%				0
Dump Activator		0.00%				0
Frame		0.00%				0
Motor Fire		0.00%				0
Other		0.00%				0
Springs		0.00%				0
Steering		0.00%				0
Suspension		0.00%				0
Throttle Sticking		0.00%				0
Tie Rod		0.00%				0
Loading & Securement		0.00%				0
Tire		0.00%				0
Trailer Door		0.00%				0
Trailer Fire		0.00%				0
Turn Lights		0.00%				0
Unknown	1	1.45%			1	14,200
Wheel Bearing		0.00%				0
Wheel Fire		0.00%				0
Wheel Separation		0.00%				0
Head Lights		0.00%				0
Parking Brake		0.00%				0
Tail Lights		0.00%				0
Transmission		0.00%				0
Electrical		0.00%				0
TOTALS	**2**	**2.90%**	**0**	**0**	**2**	**28,400**

Other:

Unknown: Not listed in report.

B30: 1993 and 1994 Idaho Data by Defect Category

Sample Size 142

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle	0	0.00%	0	0	0	0
Back Up Lights	0	0.00%	0	0	0	0
Brake Lights	0	0.00%	0	0	0	0
Brakes	3	2.11%	0	2	1	206,574
Coupling	0	0.00%	0	0	0	0
Debris Falling Off	0	0.00%	0	0	0	0
Driveshaft	0	0.00%	0	0	0	0
Dump Activator	0	0.00%	0	0	0	0
Frame	0	0.00%	0	0	0	0
Motor Fire	0	0.00%	0	0	0	0
Other	1	0.70%	0	0	1	14,200
Springs	0	0.00%	0	0	0	0
Steering	0	0.00%	0	0	0	0
Suspension	0	0.00%	0	0	0	0
Throttle Sticking	0	0.00%	0	0	0	0
Tie Rod	0	0.00%	0	0	0	0
Loading & Securement	1	0.70%	0	0	1	14,200
Tire	1	0.70%	0	1	0	96,187
Trailer Door	0	0.00%	0	0	0	0
Trailer Fire	0	0.00%	0	0	0	0
Turn Lights	0	0.00%	0	0	0	0
Unknown	1	0.70%	0	0	1	14,200
Wheel Bearing	0	0.00%	0	0	0	0
Wheel Fire	0	0.00%	0	0	0	0
Wheel Separation	0	0.00%	0	0	0	0
Head Lights	0	0.00%	0	0	0	0
Parking Brake	0	0.00%	0	0	0	0
Tail Lights	0	0.00%	0	0	0	0
Transmission	0	0.00%	0	0	0	0
Electrical	0	0.00%	0	0	0	0
TOTALS	**7**	**4.93%**	**0**	**3**	**4**	**345,361**

Unknown: Not listed in report.

APPENDIX B6

Delaware Database

Appendix B6 contains CMV accident data from the state of Deleware. Tables B31 and B32 contain the data collected from the accident reports indicating a mechanical defect as a contributing factor. Table B33 groups the accident data into specific defect categories. Tables B34, B35, and B36 sum the accident data into broad categories and give occurrences, proportions, and costs for each of the broad categories.

Table B31: 1993 Delaware Accident Report Data

State	Date	Report No.	Truck Type	Listed Defect1	Def. 2	Def. 3	Specific Sub-Item	Contributing Circumstance	Injury #1	Inj #2	Inj #3	Driver/ Inspector Opinion	Notes from Narrative
DE	2/26/93	32-93-019599	6 Wheel truck	parking brake	*	*	*	Mech. Defect	*	*	*	Driver	Driver said truck rolled back while parked
DE	6/28/93	03-93-8412	Dump	Axle fell off	*	*	*	Mech. Defect	*	*	*	N/A	Axle fell off and hit moose lodge
DE	11/30/93	32-93-122580	Tractor trailer	tire fell off	*	*	*	Mech. Defect	*	*	*	N/A	Inner tire of dual set came off and hit other vehicle
DE	12/20/93	07-93-26268	Tractor trailer	trailer disconnect	*	*	*	Mech. Defect	*	*	*	N/A	Trailer came off and rolled over

Table B32: 1994 Delaware Accident Report Data

State	Date	Report No.	Truck Type	Listed Defect1	Def. 2	Def. 3	Specific Sub-Item	Contributing Circumstance	Injury #1	Inj #2	Inj #3	Driver/ Inspector Opinion	Notes from Narrative
DE	5/19/94	32-94-48512	Tractor trailer	wheel fell off	*	*		Mech. Defect	*	*	*	N/A	Tire/wheel fell of of trailer. Hit by other vehicle
DE	1/5/94	91-94-100128	Tractor trailer	Steering	*	*		Mech. Defect	possible	*	*	Inspector	Steering disconnected from steering box.
DE	2/24/94	06-94-14119	6 wheel truck	Steering	*	*	Tie Rod	Mech. Defect	*	*	*	Inspector	Tie rod unbolted. Wheel turned, causing wreck.
DE	8/9/94	06-94-60210	Tractor trailer	Drive shaft	*	*		Mech. Defect	*	*	*	N/A	Drive shaft fell off. Hit by other vehicles

Table B33: 1993 and 1994 Delaware Data by Specific Defect

	Source	DE				
	Sample Size	86				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Accessories	Gauges (all)	0				0
Accessories	Horn	0				0
Accessories	Hydraulic lift	0				0
Accessories	Other or unknown	0				0
Accessories	Speedometer	0				0
Accessories	Windshield wiper control	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Axle	Adjustable	0				0
Axle	Axle shaft broken	0				0
Axle	Fell off	1			1	14,200
Axle	Multi-speed mechanisms	0				0
Axle	Non-drive	0				0
Axle	Other or unknown	0				0
Sum		**1**	**0**	**0**	**1**	**14,200**
Body	Battery casing	0				0
Body	Cab doors	0				0
Body	Cargo box, van	0				0
Body	Cargo doors, trailer body panels, floor, etc.	0				0
Body	Cargo heater or refrigeration unit	0				0
Body	Cargo tank	0				0
Body	Distance from end of trailer to protection device exceeded.	0				0
Body	Hold-down latch or tilting mechanism	0				0
Body	Interior	0				0
Body	Other or unknown	0				0
Body	Rear load ramp height	0				0
Body	Spare tire rack	0				0
Body	Trailer support (landing gear)	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Brakes	121 brake system	0				0
Brakes	Adjustment	0				0
Brakes	Air Chambers (Diaphragm)	0				0
Brakes	Air or vacuum booster	0				0
Brakes	Air Valve	0				0
Brakes	Brake linings contaminated	0				0
Brakes	Check valve	0				0
Brakes	Compressor	0				0
Brakes	Couplings (glad hands, etc.)	0				0
Brakes	Cracked lining	0				0
Brakes	Cylinder seal	0				0

Table B33: 1993 and 1994 Delaware Data by Specific Defect

	Source	DE				
	Sample Size	86				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Brakes	Disconnected	0				0
Brakes	Drums	0				0
Brakes	Hydraulic pump or accumulator	0				0
Brakes	Improper installation	0				0
Brakes	Lines	0				0
Brakes	Lining wear	0				0
Brakes	Linings, shoes, fasteners, drum, clevis pin	0				0
Brakes	Low air or vacuum indicator	0				0
Brakes	Master cylinder	0				0
Brakes	Other or unknown	0				0
Brakes	Parking brake	1			1	14,200
Brakes	Pedal, foot valve	0				0
Brakes	Pressure relief valve	0				0
Brakes	Springs, cams, adjusters, actuator valve	0				0
Brakes	Wheel cylinder	0				0
Sum		**1**	**0**	**0**	**1**	**14,200**
Cooling system	Belt water pump	0				0
Cooling system	Hoses, clamps, cap, thermostat, shutters	0				0
Cooling system	Other or unknown	0				0
Cooling system	Radiator	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Coupling	Breakaway device	0				0
Coupling	Fifth wheel	0				0
Coupling	Fifth wheel kingpin	0				0
Coupling	Fifth wheel plate	0				0
Coupling	Locking and Release mechanism	0				0
Coupling	Mounting, welds, u-bolts	0				0
Coupling	Not properly engaged	0				0
Coupling	Other or unknown	1			1	14,200
Coupling	Pintle Hook	0				0
Coupling	Saddle mount	0				0
Coupling	Spindle broken	0				0
Coupling	Tow bar, ball & socket, etc.	0				0
Sum		**1**	**0**	**0**	**1**	**14,200**
Driveline	Carrier bearings	0				0
Driveline	Differential failure	0				0
Driveline	Fell out (part or all)	1			1	14,200
Driveline	Other or unknown	0				0
Driveline	Shaft broke	0				0
Driveline	Universal joints	0				0

Table B33: 1993 and 1994 Delaware Data by Specific Defect

	Source	DE				
	Sample Size	86				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Sum		**1**	**0**	**0**	**1**	**14,200**
Electrical	Battery, cables	0				0
Electrical	Fuses, circuit breakers	0				0
Electrical	Generator, alternator, voltage regulator	0				0
Electrical	Ingnition system	0				0
Electrical	Instruments, controls	0				0
Electrical	Lights, brake	0				0
Electrical	Lights, head	0				0
Electrical	Lights, other	0				0
Electrical	Lights, reverse	0				0
Electrical	Lights, tail	0				0
Electrical	Lights, turn and hazard	0				0
Electrical	Other or unknown	0				0
Electrical	Wiring (Cargo area)	0				0
Electrical	Wiring (power unit)	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Engine	Air blower	0				0
Engine	Crankshaft, internals	0				0
Engine	Flywheel, vib. dampener	0				0
Engine	Oil pump, lube system	0				0
Engine	Other or Unknown	0				0
Engine	Timing gear	0				0
Engine	Valve train	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Exhaust	Exhaust pipe, hangers	0				0
Exhaust	Other or unknown	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Frame	Cross members	0				0
Frame	Other or Unknown	0				0
Frame	Rails and reinforcement	0				0
Frame	Rivets, bolts, welds	0				0
Frame	Stabilizer Bars	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Fuel System	Carburetor	0				0
Fuel System	Fuel filters	0				0
Fuel System	Fuel lines, valves	0				0
Fuel System	Fuel pump	0				0
Fuel System	Fuel tank	0				0
Fuel System	Injection pump	0				0
Fuel System	Other or unknown	0				0
Fuel System	Throttle linkage	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Load Securement	Baffles (cargo tank)	0				0
Load Securement	Battery casing fell off	0				0
Load Securement	Bolts holding tank failed	0				0
Load Securement	Bracing (metal rolls)	0				0
Load Securement	Other or Unknown	0				0

Table B33: 1993 and 1994 Delaware Data by Specific Defect

	Source	DE				
	Sample Size	86				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Load Securement	Part of load fell out	0				0
Load Securement	Tie downs, chains, etc.	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Other or Unknown		0				0
Sum		**0**	**0**	**0**	**0**	**0**
Steering	Ball & socket	0				0
Steering	Disconnected from box	1		1		96,187
Steering	gear	0				0
Steering	linkage, drag link, tie rod	0				0
Steering	Other or unknown	0				0
Steering	power steering system	0				0
Steering	Steering box loose	0				0
Steering	Steering wheel, column shaft	0				0
Steering	Tie rod (loose)	1			1	14,200
Sum		2	0	1	1	110,387
Suspension	Air bags, controls, piping	0				0
Suspension	Arms, torque, rods, walking beams	0				0
Suspension	Bushings, pivots, bearings	0				0
Suspension	Other or unknown	0				0
Suspension	Shackle, pin, hanger	0				0
Suspension	Shocks and mountings	0				0
Suspension	Spring	0				0
Suspension	Torsion bars, stabilizer, mountings	0				0
Suspension	U-bolts holding spring	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Tires	Blowout	0				0
Tires	Low pressure	0				0
Tires	Original tread	0				0
Tires	Other or unknown	1			1	14,200
Tires	Overloaded	0				0
Tires	Recap or retread	0				0
Tires	Sidewall separation	0				0
Tires	Tread, worn	0				0
Tires	Tread separation	0				0
Tires	Tube, or tube valve	0				0
Sum		**1**	**0**	**0**	**1**	**14,200**
Transmission	All auxiliary failures	0				0
Transmission	Automatic tran. internal	0				0
Transmission	Clutch	0				0
Transmission	Clutch linkage	0				0
Transmission	Manual tran. internal	0				0
Transmission	Other or Unknown	0				0

Table B33: 1993 and 1994 Delaware Data by Specific Defect

	Source	DE				
	Sample Size	86				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Transmission	Shift controls & linkage	0				0
Sum		**0**	**0**	**0**	**0**	**0**
Wheels	Leaking grease	0				0
Wheels	Other of Unknown	1			1	14,200
Wheels	Rims, flange, ring, hub, fasteners	0				0
Wheels	Studs, lugs, fasteners	0				0
Wheels	Wheel bearings	0				0
Wheels	Wheel hubs	0				0
Wheels	Wheel spacer	0				0
Sum		**1**	**0**	**0**	**1**	**14,200**
Totals		**8**	**0**	**1**	**7**	**195,587**

Table B34: 1993 Delaware Data by Defect Category

Sample Size 43

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle	1	2.33%			1	14,200
Back Up Lights		0.00%				0
Brake Lights		0.00%				0
Brakes		0.00%				0
Coupling	1	2.33%			1	14,200
Debris Falling Off		0.00%				0
Driveshaft		0.00%				0
Dump Activator		0.00%				0
Frame		0.00%				0
Motor Fire		0.00%				0
Other		0.00%				0
Springs		0.00%				0
Steering		0.00%				0
Suspension		0.00%				0
Throttle Sticking		0.00%				0
Tie Rod		0.00%				0
Loading & Securement		0.00%				0
Tire	1	2.33%			1	14,200
Trailer Door		0.00%				0
Trailer Fire		0.00%				0
Turn Lights		0.00%				0
Unknown		0.00%				0
Wheel Bearing		0.00%				0
Wheel Fire		0.00%				0
Wheel Separation		0.00%				0
Head Lights		0.00%				0
Parking Brake	1	2.33%			1	14,200
Tail Lights		0.00%				0
Transmission		0.00%				0
Electrical		0.00%				0
TOTALS	**4**	**9.30%**	**0**	**0**	**4**	**56,800**

Other:

Unknown:

Table B35: 1994 Delaware Data by Defect Category

Sample Size 43

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle		0.00%				0
Back Up Lights		0.00%				0
Brake Lights		0.00%				0
Brakes		0.00%				0
Coupling		0.00%				0
Debris Falling Off		0.00%				0
Driveshaft	1	2.33%			1	14,200
Dump Activator		0.00%				0
Frame		0.00%				0
Motor Fire		0.00%				0
Other		0.00%				0
Springs		0.00%				0
Steering	2	4.65%		1	1	110,387
Suspension		0.00%				0
Throttle Sticking		0.00%				0
Tie Rod		0.00%				0
Loading & Securement		0.00%				0
Tire		0.00%				0
Trailer Door		0.00%				0
Trailer Fire		0.00%				0
Turn Lights		0.00%				0
Unknown		0.00%				0
Wheel Bearing		0.00%				0
Wheel Fire		0.00%				0
Wheel Separation	1	2.33%			1	14,200
Head Lights		0.00%				0
Parking Brake		0.00%				0
Tail Lights		0.00%				0
Transmission		0.00%				0
Electrical		0.00%				0
TOTALS	**4**	**9.30%**	**0**	**1**	**3**	**138,787**

Other:

Unknown:

Table B36: 1993 and 1994 Delaware Data by Defect Category

Sample Size 86

Estimated Cost / Crash	
PDO	$14,200
Injury	$96,187
Fatality	$3,553,939

Defect	No.	% of sample	Fatal	Inj.	PDOs	Cost
Axle	1	1.16%	0	0	1	14,200
Back Up Lights	0	0.00%	0	0	0	0
Brake Lights	0	0.00%	0	0	0	0
Brakes	0	0.00%	0	0	0	0
Coupling	1	1.16%	0	0	1	14,200
Debris Falling Off	0	0.00%	0	0	0	0
Driveshaft	1	1.16%	0	0	1	14,200
Dump Activator	0	0.00%	0	0	0	0
Frame	0	0.00%	0	0	0	0
Motor Fire	0	0.00%	0	0	0	0
Other	0	0.00%	0	0	0	0
Springs	0	0.00%	0	0	0	0
Steering	2	2.33%	0	1	1	110,387
Suspension	0	0.00%	0	0	0	0
Throttle Sticking	0	0.00%	0	0	0	0
Tie Rod	0	0.00%	0	0	0	0
Loading & Securement	0	0.00%	0	0	0	0
Tire	1	1.16%	0	0	1	14,200
Trailer Door	0	0.00%	0	0	0	0
Trailer Fire	0	0.00%	0	0	0	0
Turn Lights	0	0.00%	0	0	0	0
Unknown	0	0.00%	0	0	0	0
Wheel Bearing	0	0.00%	0	0	0	0
Wheel Fire	0	0.00%	0	0	0	0
Wheel Separation	1	1.16%	0	0	1	14,200
Head Lights	0	0.00%	0	0	0	0
Parking Brake	1	1.16%	0	0	1	14,200
Tail Lights	0	0.00%	0	0	0	0
Transmission	0	0.00%	0	0	0	0
Electrical	0	0.00%	0	0	0	0
TOTALS	**8**	**9.30%**	**0**	**1**	**7**	**195,587**

Other:

Unknown:

APPENDIX B7

Combined Database

Appendix B7 contains Table B37 which lists the occurrences and costs for specific defects for the six states sampled.

Table B37: 1993 and 1994 Combined State Data by Specific Defect

	Source	COMBINED				
	Sample Size	3888				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Accessories	Gauges (all)	0	0	0	0	0
Accessories	Horn	0	0	0	0	0
Accessories	Hydraulic lift	0	0	0	0	0
Accessories	Other or unknown	0	0	0	0	0
Accessories	Speedometer	0	0	0	0	0
Accessories	Windshield wiper control	0	0	0	0	0
Sum		**0**	**0**	**0**	**0**	**0**
Axle	Adjustable	0	0	0	0	0
Axle	Axle shaft broken	1	0	0	1	14,200
Axle	Fell off	1	0	0	1	14,200
Axle	Multi-speed mechanisms	0	0	0	0	0
Axle	Non-drive	0	0	0	0	0
Axle	Other or unknown	0	0	0	0	0
Sum		**2**	**0**	**0**	**2**	**28,400**
Body	Battery casing	1	0	0	1	14,200
Body	Cab doors	0	0	0	0	0
Body	Cargo box, van	0	0	0	0	0
Body	Cargo doors, trailer body panels, floor, etc.	2	0	0	2	28,400
Body	Cargo heater or refrigeration unit	0	0	0	0	0
Body	Cargo tank	0	0	0	0	0
Body	Distance from end of trailer to protection device exceeded.	0	0	0	0	0
Body	Hold-down latch or tilting mechanism	0	0	0	0	0
Body	Interior	0	0	0	0	0
Body	Other or unknown	3	0	2	1	206,574
Body	Rear load ramp height	0	0	0	0	0
Body	Spare tire rack	1	0	0	1	14,200
Body	Trailer support (landing gear)	0	0	0	0	0
Sum		**7**	**0**	**2**	**5**	**263,374**
Brakes	121 brake system	0	0	0	0	0
Brakes	Adjustment	1	0	1	0	96,187
Brakes	Air Chambers (Diaphragm)	0	0	0	0	0
Brakes	Air or vacuum booster	0	0	0	0	0
Brakes	Air Valve	0	0	0	0	0
Brakes	Brake linings contaminated	0	0	0	0	0
Brakes	Check valve	0	0	0	0	0
Brakes	Compressor	0	0	0	0	0
Brakes	Couplings (glad hands, etc.)	0	0	0	0	0
Brakes	Cracked lining	0	0	0	0	0
Brakes	Cylinder seal	0	0	0	0	0

Table B37: 1993 and 1994 Combined State Data by Specific Defect

	Source	COMBINED				
	Sample Size	3888				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Brakes	Disconnected	0	0	0	0	0
Brakes	Drums	0	0	0	0	0
Brakes	Hydraulic pump or accumulator	0	0	0	0	0
Brakes	Improper installation	0	0	0	0	0
Brakes	Lines	3	0	1	2	124,587
Brakes	Lining wear	0	0	0	0	0
Brakes	Linings, shoes, fasteners, drum, clevis pin	0	0	0	0	0
Brakes	Low air or vacuum indicator	0	0	0	0	0
Brakes	Master cylinder	0	0	0	0	0
Brakes	Other or unknown	52	0	27	25	2,952,049
Brakes	Parking brake	6	0	1	5	167,187
Brakes	Pedal, foot valve	0	0	0	0	0
Brakes	Pressure relief valve	0	0	0	0	0
Brakes	Springs, cams, adjusters, actuator valve	0	0	0	0	0
Brakes	Wheel cylinder	3	0	3	0	288,561
Sum		**65**	**0**	**33**	**32**	**3,628,571**
Cooling system	Belt water pump	0	0	**0**	0	0
Cooling system	Hoses, clamps, cap, thermostat, shutters	0	0	0	0	0
Cooling system	Other or unknown	0	0	**0**	0	0
Cooling system	Radiator	0	0	**0**	0	0
Sum		**0**	**0**	**0**	**0**	**0**
Coupling	Breakaway device	0	0	0	0	0
Coupling	Fifth wheel	0	0	0	0	0
Coupling	Fifth wheel kingpin	0	0	0	0	0
Coupling	Fifth wheel plate	0	0	0	0	0
Coupling	Locking and Release mechanism	0	0	0	0	0
Coupling	Mounting, welds, u-bolts	0	0	0	0	0
Coupling	Not properly engaged	0	0	0	0	0
Coupling	Other or unknown	13	0	3	10	430,561
Coupling	Pintle Hook	1	0	0	1	14,200
Coupling	Saddle mount	0	0	0	0	0
Coupling	Spindle broken	1	0	1	0	96,187
Coupling	Tow bar, ball & socket, etc.	0	0	0	0	0
Sum		**15**	**0**	**4**	**11**	**540,948**
Driveline	Carrier bearings	0	0	0	0	0
Driveline	Differential failure	0	0	0	0	0
Driveline	Fell out (part or all)	6	0	2	4	249,174
Driveline	Other or unknown	0	0	0	0	0
Driveline	Shaft broke	1	0	0	1	14,200
Driveline	Universal joints	0	0	0	0	0

Table B37: 1993 and 1994 Combined State Data by Specific Defect

	Source	COMBINED				
	Sample Size	3888				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Sum		**7**	**0**	**2**	**5**	**263,374**
Electrical	Battery, cables	0	0	0	0	0
Electrical	Fuses, circuit breakers	0	0	0	0	0
Electrical	Generator, alternator, voltage regulator	0	0	0	0	0
Electrical	Ingnition system	0	0	0	0	0
Electrical	Instruments, controls	0	0	0	0	0
Electrical	Lights, brake	1	0	1	0	96,187
Electrical	Lights, head	1	0	0	1	14,200
Electrical	Lights, other	0	0	0	0	0
Electrical	Lights, reverse	1	0	0	1	14,200
Electrical	Lights, tail	3	0	3	0	288,561
Electrical	Lights, turn and hazard	2	0	2	0	192,374
Electrical	Other or unknown	1	0	1	0	96,187
Electrical	Wiring (Cargo area)	0	0	0	0	0
Electrical	Wiring (power unit)	0	0	0	0	0
Sum		**9**	**0**	**7**	**2**	**701,709**
Engine	Air blower	0	0	0	0	0
Engine	Crankshaft, internals	0	0	0	0	0
Engine	Flywheel, vib. dampener	0	0	0	0	0
Engine	Oil pump, lube system	0	0	0	0	0
Engine	Other or Unknown	2	0	0	2	28,400
Engine	Timing gear	0	0	0	0	0
Engine	Valve train	0	0	0	0	0
Sum		**2**	**0**	**0**	**2**	**28,400**
Exhaust	Exhaust pipe, hangers	0	0	0	0	0
Exhaust	Other or unknown	0	0	0	0	0
Sum		**0**	**0**	**0**	**0**	**0**
Frame	Cross members	0	0	0	0	0
Frame	Other or Unknown	0	0	0	0	0
Frame	Rails and reinforcement	2	0	1	1	110,387
Frame	Rivets, bolts, welds	0	0	0	0	0
Frame	Stabilizer Bars	0	0	0	0	0
Sum		**2**	**0**	**1**	**1**	**110,387**
Fuel System	Carburetor	0	0	0	0	0
Fuel System	Fuel filters	0	0	0	0	0
Fuel System	Fuel lines, valves	0	0	0	0	0
Fuel System	Fuel pump	0	0	0	0	0
Fuel System	Fuel tank	0	0	0	0	0
Fuel System	Injection pump	0	0	0	0	0
Fuel System	Other or unknown	0	0	0	0	0
Fuel System	Throttle linkage	2	0	1	1	110,387
Sum		**2**	**0**	**1**	**1**	**110,387**
Load Securement	Baffles (cargo tank)	0	0	0	0	0
Load Securement	Battery casing fell off	0	0	0	0	0
Load Securement	Bolts holding tank failed	0	0	0	0	0
Load Securement	Bracing (metal rolls)	0	0	0	0	0
Load Securement	Other or Unknown	3	0	1	2	124,587

Table B37: 1993 and 1994 Combined State Data by Specific Defect

	Source	COMBINED				
	Sample Size	3888				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Load Securement	Part of load fell out	8	1	2	5	3,817,313
Load Securement	Tie downs, chains, etc.	3	0	0	3	42,600
Sum		**14**	**1**	**3**	**10**	**3,984,500**
Other or Unknown		17	2	7	8	7,894,787
Sum		**17**	**2**	**7**	**8**	**7,894,787**
Steering	Ball & socket	0	0	0	0	0
Steering	Disconnected from box	1	0	1	0	96,187
Steering	gear	0	0	0	0	0
Steering	linkage, drag link, tie rod	0	0	0	0	0
Steering	Other or unknown	1	0	0	1	14,200
Steering	power steering system	0	0	0	0	0
Steering	Steering box loose	0	0	0	0	0
Steering	Steering wheel, column shaft	0	0	0	0	0
Steering	Tie rod (loose)	2	0	0	2	28,400
Sum		4	0	1	3	138,787
Suspension	Air bags, controls, piping	0	0	0	0	0
Suspension	Arms, torque, rods, walking beams	0	0	0	0	0
Suspension	Bushings, pivots, bearings	0	0	0	0	0
Suspension	Other or unknown	1	0	1	0	96,187
Suspension	Shackle, pin, hanger	0	0	0	0	0
Suspension	Shocks and mountings	0	0	0	0	0
Suspension	Spring	1	0	0	1	14,200
Suspension	Torsion bars, stabilizer, mountings	0	0	0	0	0
Suspension	U-bolts holding spring	0	0	0	0	0
Sum		**2**	**0**	**1**	**1**	**110,387**
Tires	Blowout	14	0	7	7	772,709
Tires	Low pressure	0	0	0	0	0
Tires	Original tread	0	0	0	0	0
Tires	Other or unknown	1	0	0	1	14,200
Tires	Overloaded	0	0	0	0	0
Tires	Recap or retread	0	0	0	0	0
Tires	Sidewall separation	0	0	0	0	0
Tires	Tread, worn	2	0	1	1	110,387
Tires	Tread separation	1	0	0	1	14,200
Tires	Tube, or tube valve	0	0	0	0	0
Sum		**18**	**0**	**8**	**10**	**911,496**
Transmission	All auxiliary failures	0	0	0	0	0
Transmission	Automatic tran. internal	0	0	0	0	0
Transmission	Clutch	0	0	0	0	0
Transmission	Clutch linkage	0	0	0	0	0
Transmission	Manual tran. internal	0	0	0	0	0
Transmission	Other or Unknown	2	1	1	0	3,650,126

Table B37: 1993 and 1994 Combined State Data by Specific Defect

	Source	COMBINED				
	Sample Size	3888				
Defect Category	Specific Defect	Observed Occur-rences	Fatality Accid.	Injury Accid.	PDO Accid.	Cost
Transmission	Shift controls & linkage	0	0	0	0	0
Sum		**2**	**1**	**1**	**0**	**3,650,126**
Wheels	Leaking grease	0	0	0	0	0
Wheels	Other of Unknown	12	0	1	11	252,387
Wheels	Rims, flange, ring, hub, fasteners	0	0	0	0	0
Wheels	Studs, lugs, fasteners	0	0	0	0	0
Wheels	Wheel bearings	1	0	1	0	96,187
Wheels	Wheel hubs	0	0	0	0	0
Wheels	Wheel spacer	0	0	0	0	0
Sum		**13**	**0**	**2**	**11**	**348,574**
Totals		**181**	**4**	**73**	**104**	**22,714,207**

APPENDIX C

State Proportions and Confidence Limits

Appendix C contains Tables C1 through C6 which list the proportions, confidence limits, and costs for broad defect categories for the six states sampled.

Table C1: Florida Proportions, Confidence Limits, and Costs

Stratum 1 **Florida**

Samp. size	1,500	Population	23,292

Defect	Observed Occur-rences	Ph,i (Acc. by Defect)	Upper Confid Limit ($P_{h,I}$)	Lower Confid Limit ($P_{h,I}$)	Total Cost (in dollars)
Accessories	0	0.00%	0.200%	0.000%	0
Axle	0	0.00%	0.200%	0.000%	0
Body	2	0.13%	0.419%	0.024%	110,387
Brakes	27	1.80%	2.474%	1.273%	1,859,166
Cooling System	0	0.00%	0.200%	0.000%	0
Coupling	1	0.07%	0.316%	0.003%	96,187
Driveline	3	0.20%	0.516%	0.055%	206,574
Electrical	6	0.40%	0.788%	0.174%	577,122
Engine	1	0.07%	0.316%	0.003%	14,200
Exhaust	0	0.00%	0.200%	0.000%	0
Frame	1	0.07%	0.316%	0.003%	96,187
Fuel System	0	0.00%	0.200%	0.000%	0
Load Securement	6	0.40%	0.788%	0.174%	249,174
Other or Unknown	7	0.47%	0.875%	0.219%	3,967,087
Steering	0	0.00%	0.200%	0.000%	0
Suspension	0	0.00%	0.200%	0.000%	0
Tires	9	0.60%	1.045%	0.313%	619,722
Transmission	2	0.13%	0.419%	0.024%	3,650,126
Wheels	1	0.07%	0.316%	0.003%	96,187
TOTALS	**66**	**4.40%**			**11,542,119**

Table C2: Ohio Proportions, Confidence Limits, and Costs

Stratum 1 **Ohio**

Samp. size:	1,011	Population:	31,883

Defect	Observed Occur-rences	$P_{h,I}$ (Acc. by Defect)	Upper Confid Limit ($P_{h,I}$)	Lower Confid Limit ($P_{h,I}$)	Total Cost (in dollars)
Accessories	0	0.00%	0.296%	0.000%	0
Axle	0	0.00%	0.296%	0.000%	0
Body	4	0.40%	0.903%	0.135%	138,787
Brakes	8	0.79%	1.423%	0.394%	523,535
Cooling System	0	0.00%	0.296%	0.000%	0
Coupling	4	0.40%	0.903%	0.135%	56,800
Driveline	3	0.30%	0.765%	0.081%	42,600
Electrical	1	0.10%	0.468%	0.005%	14,200
Engine	0	0.00%	0.296%	0.000%	0
Exhaust	0	0.00%	0.296%	0.000%	0
Frame	0	0.00%	0.296%	0.000%	0
Fuel System	0	0.00%	0.296%	0.000%	0
Load Securement	0	0.00%	0.296%	0.000%	0
Other or Unknown	2	0.20%	0.621%	0.035%	28,400
Steering	0	0.00%	0.296%	0.000%	0
Suspension	0	0.00%	0.296%	0.000%	0
Tires	2	0.20%	0.621%	0.035%	28,400
Transmission	0	0.00%	0.296%	0.000%	0
Wheels	3	0.30%	0.765%	0.081%	124,587
TOTALS	**27**	**2.67%**			**957,309**

$P_{h,I}$	Acc. proportion of state i, strata h	=(number of accidents possessing characteristic)/$n_{h,i}$
P_h	Proportion of strata h	=($P_{h,1}$+$P_{h,2}$)/(# of states in strata)
$n_{h,I}$	Sample population for state i in strata h	

Table C3: Missouri Proportions, Confidence Limits, and Costs

Stratum 2 **Missouri**

Samp. size	754	Population	8052

Defect	Observed Occur-rences	$P_{h,i}$ (Acc. by Defect)	Upper Confid Limit ($P_{h,i}$)	Lower Confid Limit ($P_{h,i}$)	Total Cost (in dollars)
Accessories	0	0.000%	0.397%	0.000%	0
Axle	1	0.133%	0.628%	0.007%	14,200
Body	0	0.000%	0.397%	0.000%	0
Brakes	17	2.255%	3.363%	1.442%	569,348
Cooling System	0	0.000%	0.397%	0.000%	0
Coupling	9	1.194%	2.074%	0.624%	373,761
Driveline	0	0.000%	0.397%	0.000%	0
Electrical	2	0.265%	0.833%	0.047%	110,387
Engine	1	0.133%	0.628%	0.007%	14,200
Exhaust	0	0.000%	0.397%	0.000%	0
Frame	0	0.000%	0.397%	0.000%	0
Fuel System	1	0.133%	0.628%	0.007%	14,200
Load Securement	4	0.531%	1.210%	0.181%	138,787
Other or Unknown	5	0.663%	1.389%	0.262%	3,856,700
Steering	2	0.265%	0.833%	0.047%	28,400
Suspension	0	0.000%	0.397%	0.000%	0
Tires	3	0.398%	1.025%	0.109%	124,587
Transmission	0	0.000%	0.397%	0.000%	0
Wheels	8	1.061%	1.906%	0.529%	113,600
TOTALS	53	7.03%			5,358,170

Table C4: Washington Proportions, Confidence Limits, and Costs

Stratum 2 **Washington**

Samp. size	395	Population	12619

Defect	Observed Occur-rences	$P_{h,i}$ (Acc. by Defect)	Upper Confid Limit ($P_{h,i}$)	Lower Confid Limit ($P_{h,i}$)	Total Cost (in dollars)
Accessories	0	0.00%	0.756%	0.000%	0
Axle	0	0.00%	0.756%	0.000%	0
Body	1	0.25%	1.195%	0.013%	14,200
Brakes	9	2.28%	3.942%	1.194%	455,748
Cooling System	0	0.00%	0.756%	0.000%	0
Coupling	0	0.00%	0.756%	0.000%	0
Driveline	0	0.00%	0.756%	0.000%	0
Electrical	0	0.00%	0.756%	0.000%	0
Engine	0	0.00%	0.756%	0.000%	0
Exhaust	0	0.00%	0.756%	0.000%	0
Frame	1	0.25%	1.195%	0.013%	14,200
Fuel System	1	0.25%	1.195%	0.013%	96,187
Load Securement	3	0.76%	1.951%	0.207%	3,582,339
Other or Unknown	1	0.25%	1.195%	0.013%	14,200
Steering	0	0.00%	0.756%	0.000%	0
Suspension	2	0.51%	1.585%	0.090%	110,387
Tires	2	0.51%	1.585%	0.090%	28,400
Transmission	0	0.00%	0.756%	0.000%	0
Wheels	0	0.00%	0.756%	0.000%	0
TOTALS	20	5.06%			4,315,661

$P_{h,i}$	Acc. proportion of state i, strata h	=(number of accidents possessing characteristic)/$n_{h,i}$
P_h	Proportion of strata h	=($P_{h,1}$+$P_{h,2}$)/(# of states in strata)
$n_{h,i}$	Sample population for state i in strata h	

Table C5: Idaho Proportions, Confidence Limits, and Costs

Stratum 3 **Idaho**

Samp. size	142	Population	2986

Defect	Observed Occur-rences	$P_{h,i}$ (Acc. by Defect)	Upper Confid Limit ($P_{h,i}$)	Lower Confid Limit ($P_{h,i}$)	Total Cost (in dollars)
Accessories	0	0.00%	2.088%	0.000%	0
Axle	0	0.00%	2.088%	0.000%	0
Body	0	0.00%	2.088%	0.000%	0
Brakes	3	2.11%	5.370%	0.578%	206,574
Cooling System	0	0.00%	2.088%	0.000%	0
Coupling	0	0.00%	2.088%	0.000%	0
Driveline	0	0.00%	2.088%	0.000%	0
Electrical	0	0.00%	2.088%	0.000%	0
Engine	0	0.00%	2.088%	0.000%	0
Exhaust	0	0.00%	2.088%	0.000%	0
Frame	0	0.00%	2.088%	0.000%	0
Fuel System	0	0.00%	2.088%	0.000%	0
Load Securement	1	0.70%	3.297%	0.036%	14,200
Other or Unknown	2	1.41%	4.367%	0.251%	28,400
Steering	0	0.00%	2.088%	0.000%	0
Suspension	0	0.00%	2.088%	0.000%	0
Tires	1	0.70%	3.297%	0.036%	96,187
Transmission	0	0.00%	2.088%	0.000%	0
Wheels	0	0.00%	2.088%	0.000%	0
TOTALS	7	4.93%			345,361

Table C6: Delaware Proportions, Confidence Limits, and Costs

Stratum 3 **Delaware**

Samp. size	86	Population	2213

Defect	Observed Occur-rences	$P_{h,i}$ (Acc. by Defect)	Upper Confid Limit ($P_{h,i}$)	Lower Confid Limit ($P_{h,i}$)	Total Cost (in dollars)
Accessories	0	0.00%	3.423%	0.000%	0
Axle	1	1.16%	5.397%	0.060%	14,200
Body	0	0.00%	3.423%	0.000%	0
Brakes	1	1.16%	5.397%	0.060%	14,200
Cooling System	0	0.00%	3.423%	0.000%	0
Coupling	1	1.16%	5.397%	0.060%	14,200
Driveline	1	1.16%	5.397%	0.060%	14,200
Electrical	0	0.00%	3.423%	0.000%	0
Engine	0	0.00%	3.423%	0.000%	0
Exhaust	0	0.00%	3.423%	0.000%	0
Frame	0	0.00%	3.423%	0.000%	0
Fuel System	0	0.00%	3.423%	0.000%	0
Load Securement	0	0.00%	3.423%	0.000%	0
Other or Unknown	0	0.00%	3.423%	0.000%	0
Steering	2	2.33%	7.140%	0.415%	110,387
Suspension	0	0.00%	3.423%	0.000%	0
Tires	1	1.16%	5.397%	0.060%	14,200
Transmission	0	0.00%	3.423%	0.000%	0
Wheels	1	1.16%	5.397%	0.060%	14,200
TOTALS	8	9.30%			195,587

$P_{h,i}$	Acc. proportion of state i, strata h	=(number of accidents possessing characteristic)/$n_{h,i}$
P_h	Proportion of strata h	=($P_{h,1}$+$P_{h,2}$)/(# of states in strata)
$n_{h,i}$	Sample population for state i in strata h	

APPENDIX D

Strata Proportions and Confidence Limits

Appendix D contains Tables D1 through D3 which lists the proportions, confidence limits, and costs for broad defect categories for the three strata.

Table D1: Stratum 1 Proportions, Confidence Limits, and Costs

Stratum 1 **Combined**

Samp. size	2,511	Population:	55,175

Defect	p_h (% for Strata)	Upper Confid Limit (P_h)	Lower Confid Limit (P_h)	Total Cost (in dollars)
Accessories	0.00%	0.119%	0.000%	0
Axle	0.00%	0.119%	0.000%	0
Body	0.26%	0.471%	0.104%	249,174
Brakes	1.30%	1.844%	1.032%	2,382,701
Cooling System	0.00%	0.119%	0.000%	0
Coupling	0.23%	0.418%	0.078%	152,987
Driveline	0.25%	0.471%	0.104%	249,174
Electrical	0.25%	0.523%	0.131%	591,322
Engine	0.03%	0.189%	0.002%	14,200
Exhaust	0.00%	0.119%	0.000%	0
Frame	0.03%	0.189%	0.002%	96,187
Fuel System	0.00%	0.119%	0.000%	0
Load Securement	0.20%	0.471%	0.104%	249,174
Other or Unknown	0.33%	0.625%	0.187%	3,995,487
Steering	0.00%	0.119%	0.000%	0
Suspension	0.00%	0.119%	0.000%	0
Tires	0.40%	0.724%	0.246%	648,122
Transmission	0.07%	0.251%	0.014%	3,650,126
Wheels	0.18%	0.364%	0.054%	220,774
TOTALS	**3.54%**			**12,499,428**

Table D2: Stratum 2 Proportions, Confidence Limits, and Costs

Stratum 2 **Combined**

Samp. size	1149	Population:	20671

Defect	p_h (% for Strata)	Upper Confid Limit (P_h)	Lower Confid Limit (P_h)	Total Cost (in dollars)
Accessories	0.00%	0.260%	0.000%	0
Axle	0.07%	0.412%	0.004%	14,200
Body	0.13%	0.412%	0.004%	14,200
Brakes	2.27%	3.126%	1.590%	1,025,096
Cooling System	0.00%	0.260%	0.000%	0
Coupling	0.60%	1.363%	0.409%	373,761
Driveline	0.00%	0.260%	0.000%	0
Electrical	0.13%	0.547%	0.031%	110,387
Engine	0.07%	0.412%	0.004%	14,200
Exhaust	0.00%	0.260%	0.000%	0
Frame	0.13%	0.412%	0.004%	14,200
Fuel System	0.19%	0.547%	0.031%	110,387
Load Securement	0.64%	1.141%	0.286%	3,721,126
Other or Unknown	0.46%	1.028%	0.228%	3,870,900
Steering	0.13%	0.547%	0.031%	28,400
Suspension	0.25%	0.547%	0.031%	110,387
Tires	0.45%	0.913%	0.172%	152,987
Transmission	0.00%	0.260%	0.000%	0
Wheels	0.53%	1.253%	0.347%	113,600
TOTALS	6.05%			**9,673,831**

Table D3: Stratum 3 Proportions, Confidence Limits, and Costs

Stratum 3 **Combined**

Samp. size	228	Population:	5199

Defect	p_h (% for Strata)	Upper Confid Limit (P_h)	Lower Confid Limit (P_h)	Total Cost (in dollars)
Accessories	0.00%	1.305%	0.000%	0
Axle	0.58%	2.064%	0.022%	14,200
Body	0.00%	1.305%	0.000%	0
Brakes	1.64%	3.969%	0.601%	220,774
Cooling System	0.00%	1.305%	0.000%	0
Coupling	0.58%	2.064%	0.022%	14,200
Driveline	0.58%	2.064%	0.022%	14,200
Electrical	0.00%	1.305%	0.000%	0
Engine	0.00%	1.305%	0.000%	0
Exhaust	0.00%	1.305%	0.000%	0
Frame	0.00%	1.305%	0.000%	0
Fuel System	0.00%	1.305%	0.000%	0
Load Securement	0.35%	2.064%	0.022%	14,200
Other or Unknown	0.70%	2.735%	0.156%	28,400
Steering	1.16%	2.735%	0.156%	110,387
Suspension	0.00%	1.305%	0.000%	0
Tires	0.93%	2.735%	0.156%	110,387
Transmission	0.00%	1.305%	0.000%	0
Wheels	0.58%	2.064%	0.022%	14,200
TOTALS	**7.12%**			**540,948**

Confidence interval =	90%
P2 - P1 =	90%
P1	0.05
P2	0.95

APPENDIX E

National Proportion and Occurrence Estimates (including Confidence Limits) from the OSU Sampling Study

Appendix E contains Table E1 which lists the national estimated proportions, confidence limits on the proportions, national estimated occurrences, and confidence limits on the occurrences for the OSU sampling study.

Table E1: National Proportions, Occurrences, and Confidence Limits for OSU Sample

Assumed Strata Pop (two years) N1 = 468,570 N2 = 289,419 N3 = 42,011

National Population (two years) = N = N1 + N2 + N3 = 800,000

National Population (one year) = 400,000

Sample Population 3,888

Defect	Proportion Estimate (P^)	Sample Occurrences	P^ Upper Confid. Limit	P^ Lower Confid. Limit	Occurrences Estimate (*t*)	*t* Upper Confid. Limit	*t* Lower Confid. Limit	Total Cost Observed in Sample
Accessories	0.000%	0	0.077%	0.000%	0	308	0	0
Axle	0.055%	2	0.162%	0.009%	218	647	37	28,400
Body	0.201%	7	0.338%	0.085%	803	1,352	338	263,374
Brakes	1.665%	65	2.051%	1.348%	6659	8,205	5,392	3,628,571
Cooling System	0.000%	0	0.077%	0.000%	0	308	0	0
Coupling	0.382%	15	0.593%	0.238%	1527	2,374	952	540,948
Driveline	0.176%	7	0.338%	0.085%	704	1,352	338	263,374
Electrical	0.194%	9	0.404%	0.121%	776	1,614	483	701,709
Engine	0.044%	2	0.162%	0.009%	174	647	37	28,400
Exhaust	0.000%	0	0.077%	0.000%	0	308	0	0
Frame	0.065%	2	0.162%	0.009%	261	647	37	110,387
Fuel System	0.070%	2	0.162%	0.009%	279	647	37	110,387
Load Securemen	0.369%	14	0.562%	0.218%	1476	2,249	871	3,984,500
Other or Unknown	0.397%	17	0.655%	0.279%	1589	2,621	1,115	7,894,787
Steering	0.109%	4	0.235%	0.035%	436	941	141	138,787
Suspension	0.092%	2	0.162%	0.009%	366	647	37	110,387
Tires	0.446%	18	0.686%	0.299%	1785	2,743	1,198	911,496
Transmission	0.039%	2	0.162%	0.009%	156	647	37	3,650,126
Wheels	0.329%	13	0.531%	0.198%	1316	2,124	792	348,574
Totals	**4.632%**	**181**	**5.250%**	**4.112%**	**18,527**	**20,999**	**16,449**	**$22,714,207**

P^ = Estimated proportion for USA =(N1*P1 + N2*P2 + N3*P3)/N

High and Low Ranges calculated with a 90% confidence interval.
Confidence interval = 90% p1 = 0.05
p2 - p1 = 90% p2 = 0.95

P^ Upper confidence limit = $\frac{(Xo+1) * FINVp1(2*(Xo+1), 2*(n-Xo))}{(n-Xo) + (Xo+1) * FINVp1(2*(Xo+1), 2*(n-Xo))}$

P^ Lower confidence limit = $\frac{Xo}{(n-Xo+1) * FINVp2(2*(n-Xo+1), 2*Xo) + Xo}$

N1 = Accident population of stratum 1

N = Accident population for all fifty states. (= N1 + N2 + N3)

P1 = Proportion of defect in stratum 1

t = Estimated USA total (one year) containing characteristic = N(one year) * p

APPENDIX F1

Summary of
National Transportation Safety Board
Motor Carrier Safety Study

Appendix F1 contains Table F1 which lists the CMV accident information taken from the National Transportation Safety Board Motor Carrier Safety Study. The information was utilized as part of the accident inspection database.

Table F1: National Transportation Safety Board Accident Inspection Data

Case No.	Truck Type	Description	Injuries	Noted Defects	Other Defect	Notes On Defects/Probable Cause
182	80 Mack COE w/ loaded van trailer	When accelerator mechanism broke, truck was unable to stop before going through a toll booth.	1 fatality, 1 injury	Accelerator Mechanism (not an OOSC)	*	Inspection revealed that springs were not found on the throttle linkage, and tests revealed that the the accelerator could stick in the open position. NTSB states the malfunction of the accelerator mechanism as probable cause.
6	1968 Peterbilt COE tractor w/ 20-ft. loaded bottom dump trailers	Traversing 7% grade approaching railroad grade crossing. Struck the RR engine.	1 injured	Brakes	*	On power unit, one brake was inoperative, the other out of adj. On converter dolly and trailers, 5 of 6 brakes were out of adj. NTSB states failure of brakes as probable cause.
14	1975 Mack w/ loaded flatbed trailer	Traveling down a 6% grade, truck lost brakes and entered escape ramp. Traversed ramp and vaulted 60 ft.	2 fatals 1 injured	Brakes	Tires	6 of 8 brakes on combination unit out of adjustment, the push-rod of each brake up to its max. travel. Two remaining brakes too damaged to tell. Inadequate tread depth for majority of tires. NTSB states maladjustment of brakes as probable cause.
19	1980 COE Ford w/ 2 loaded trailers	Traversing 1 3.2 mi. winding downgrade, brakes failed	1 injured	Brakes	*	All the brakes on the truck were improperly adjusted, drums were grooved and showed excessive wear. NTSB states maladjustment of brakes as probable cause.
20	77 Mack 3-axle tractor w/ flatbed loaded	Traveling 45-50 MPH, a 4-dr. sedan attempts a U-turn in driver's path. 4 of 6 occupants killed. Truck driver not injured.	4 fatals 2 injured	Brakes	*	Factory installed front axle brakes for the power unit were disconnected. 3 of 4 remaining brakes were outside of proper adjustment. NTSB states lack of passenger car to yield as probable cause. Brakes contributed to the severity of the collision.
38	80 Mack 3-axle tractor w/ flatbed loaded	Cresting a hill, driver was unable to avoid stopped traffic. Failed in attempt to avoid and started a chain reaction involving 6 vehicles	2 injured	Brakes	*	Airbrake supply lines between power unit and trailer had been taped in frayed areas. One air line was spliced w/ heater hose and rear service air valve on trailer leaked air. Some oil seals leaked. NTSB states fatigue w/ brakes as contributing cause.
39	67 Freightliner w/ 2 flatbeds loaded	On a 6% upgrade, truck (w/ smoking brakes) attempted to pass another truck, striking its trailer which severed the steering axle. Impacted median barrier. Driver and occupant ejected.	2 fatals	Brakes	*	Service and emergency lines had been crossed and there was no braking air supplied to either trailer. Spring brake on driver's side broken. Brake linings were oil-soaked on both sides of drive axle. NTSB states poor brake system as probable cause.

Table F1: National Transportation Safety Board Accident Inspection Data

Case No.	Truck Type	Description	Injuries	Noted Defects	Other Defect	Notes On Defects/Probable Cause
42	85 Freightliner	Ran stop light and broad sided a car w/ no attempt to brake. .21 BAC.	1 fatal 1 injured	Brakes	*	6 out of 10 brakes on the truck were improperly adjusted. 4 trailer brakes were backed off past proper limits, and one of the brake shoes failed to make contact w/ drum by 1/8 in. NTSB states failure to stop due to alcohol and improperly adjusted brakes.
66	81 White conventional tractor w/ looging piggy back	On 7-12% downgrade, truck lost braking abikity, colliding w/ 7 stopped vehicles.	8 injuries	Brakes	*	Of the three axles on power unit, front axle had no brakes, second was not adjusted within tolerance, and third was in upper limit of adjustment. NTSB states inadequate brakes as probable cause.
78	84 Intl COE w/ trailer	Traversing a downgrade, trucks brakes failed, rolled and slid down an embankment.	1 fatality, 1 injury	Brakes	*	8 of the 10 brakes on the truck were out of adjustment. Only the steering axle brakes were within adjustment tolerences recommended by the manufacturer. NTSB states maladjustment of brakes and the driver's failure to check them as probable cause.
84	75 Conv. Brockway w/ loaded dump trailer	A passenger car failed to yield while attempting a left hand turn and collided with the truck.	1 fatality, 1 injury	Brakes	Tires	Inspection revealed several mechanical defects on the truck including brakes (hand valve open on airbrake supply hose) and unsafe tires. NTSB states failure to yield was the probable cause, with maladjustment of brakes as contributing cause.
93	84 Peterbilt	Traversing a downgrade, trucks brakes failed, rolled and slid crosssing the lane into an oncoming bus.	4 fatals and 1 injury	Brakes	*	Poor judgement (fatigue) in continuing his descent knowing his brakes were malfunctioning results in NTSB's conclusion that fatigue was the probable cause. NTSB states maladjustment of brakes as contributing cause.
96	81 White Fghtlnr. COE w/ 2 loaded tankers	Truck was unable to stop for traffic resulting in impact with passenger cars.	3 injuries	Brakes	*	Inspection revealed that the shoes on axle No. 5 had been improperly installed, precluding contact b/w shoe and drum. NTSB states defective brakes and a delayed response as probable cause.
115	77 COE Intl. tractor w/ loaded dump trailer	Driver failed to stop in time crushing a passenger vehicle into a flatbed truck	2 fatality, 1 injury	Brakes	*	2 of 10 brakes were in working order. Brake pads on steering axle contaminated w/ oil. and the air hoses were dry and cracked. 2nd axle brakes leaked air. 3rd axle brakes inoperative. NTSB states failure of brakes as probable cause.

Table F1: National Transportation Safety Board Accident Inspection Data

Case No.	Truck Type	Description	Injuries	Noted Defects	Other Defect	Notes On Defects/Probable Cause
128	73 Kwrth. COE w/ empty flatbed	Truck ran a red light colliding with a passenger car.	2 fatality, 1 injury	Brakes	*	Brakes on the truck were improperly adjusted; push rod stroke on the 2nd and 3rd axles 2and 1/2 inches on both sides of the axle. The front steering axle was not equipped with brakes.NTSB states maladjustment of brakes or inattention as probable cause.
134	76 Ptrblt. Cabover w/ cabover	Brakes failed and driver veered off of road to avoid stopped traffic.	none	Brakes	*	Brakes on the truck were not operable. There are no details other than the examination found numerous defects in the brake system.NTSB states failure of brakes as probable cause.
140	78 Chev. w/ car hauler	Truck crashed into a schoolbus which was stopped to offload a passsenger.	37 injuries	Brakes	*	Inspection revealed that the brake chamber push rod measurements at all wheels exceeded readjustment limits. Diaphragm of right front was ruptured. NTSB states inattention as probable cause. Brakes contributing to severity.
144	84 Mack Dumptruck	Dumptruck swerved to avoid collision striking a schoolbus.	34 injuries	Brakes	Steering	Rear brake drums were scored beyond safe limits and excessive steering play from a loose tie rod was detected. NTSB states driver's failure to keep a safe distance between vehicles as the probable cause. Brakes and steering were contributing factors.
146	82 GMC COE 3-axle w/ loaded tanker	Driver travelling down a mountain grade was unable to get the truck into the proper gearing. Applying the brakes didn't help as they failed to respond. Truck left roadway and flipped.	1 fatality, 1 injury	Brakes	*	Inspection revealed that 6 of 9 brakes checked were out of adjustment. Most of the drums showed signs of heat cracks and discoloration. NTSB states failure of brakes as probable cause combined with driver inexperience.
155	78 Int'l. w/ loaded 41-ft. trailer	Truck was unable to stop when service brakes were applied striking a bus that was crossing in front while making a left hand turn.	31 injured	Brakes	*	Inspection revealed thattyehservice brakes were defficient as 3 wheels of the tractor were not braking. NTSB states bus driver's failure to yield as the probable cause. Insufficient brakes on the truck were a contributing circumstance.
178	87 Kwrth.w/ loaded tanker	Unable to stop at a railroad crossing, the truck is broadsided by a train.	0	Brakes	*	Inspection revealed that all of the trailer brakes were out of adjustment. The tractor was not available to be examined. NTSB states failure of brakes as probable cause combined with excessive speed to avoid a collision as probable cause.

Table F1: National Transportation Safety Board Accident Inspection Data

Case No.	Truck Type	Description	Injuries	Noted Defects	Other Defect	Notes On Defects/Probable Cause
160	82 Kwrth. w/ loaded tanker	Truck lost its trailer while boarding an interstate. Tanker dropped onto its landing gear, puncturing the tank which then ignited.	none	Coupling Devices	*	Inspection revealed that the release handle on the Holland "Type A" fifth wheel had been heated and bent at a different angle than design specs, causing the king pin to not lock securely. Failure of driver to ensure king pin was locked as probable cause.
167	77 GMC w/trailer	Truck become stuck on RR grade crosing and was struck by a train when his drive train failed.	32 injuries	Differential Drive Shaft	*	Drive shaft of the truck was fractured and had been rebuilt with used parts 6 wks. prior to accident. NTSB states the failure of the differential drive shaft as the probable cause.
110	79 Conv. Kwrth w/ flatbed	As the driver of the truck entered the freeway from being parked on the shoulder, it was struck in the rear by another truck	1 fatality, 1 injury	Lights	*	Lab analysis showed that the tailights and turn signals were not on the left rear of the semi trailer when the impact occured. NTSB states illegal and unsafe movement into travel lanes as probable cause.
63	80 White conventional truck tractor w/ empty flatbed tilt-trailer.	Truck had pulled out from a private drive w/ trailer brakes locked. Passsenger car attempted to pass truck but returned to lane because of on-coming traffic. Skidded 114 ft. before striking tilt-trailer @ 15-20mph. Driver killed.	1 fatality	Rear load ramp height	*	Height of the rear load ramp was in violation of state laws (Idaho). The height can't exceed 30 in. The ramps had a ground clearance of 34 in., the car's hood was @ 31 in. NTSB states passenger car driver as probable cause with underride contributing.
185	87 Frghtlnr. w/ van trailer	Truck failed to negotiate a curve and rolled.	1 fatality, 1 injury	Safe Loading	*	Inspection revelaed that the load, consisting of 3cribbed rolls of copper was inadequately braced. NTSB states the lateral shift of the unsecured cargo as probable cause.
69	77 Peterbilt w/ cargo tank	Truck w/ partial load of liquid sludge negotiated onramp radius turn at 10 MPH, and rolled.	none	Stabilizer Bars	*	Longitudinal baffles in cargo tank had been altered by cutting large holes in the top and bottom to allow flow from side to side. A broken stabilizer bar on third axle, and cracked stab. brace on 4th. Driver error and altered baffles as probable cause.
21	85 Mack COE w/ loaded trailer	Tire failed causing the truck to pull to the right across the road and into a drainage flume	none	Tires	*	Lab testing revealed that the tire failure was due to sidewall cord seperation that was initiated prior to impact. NTSB states the explosive failure of the truck's steering axle tire as probable cause.
103	75 White Conv. w/ tanker	Driver rolled the tanker onto its right side while travelling around a curve at 30 mph.	1 injury	Tires	*	The vehicle was found to have low tire pressure in six of the nine right side tires, 4 of them below 40 psi. NTSB states a combination of excessive speed and the low air pressure as probable cause.

Table F1: National Transportation Safety Board Accident Inspection Data

Case No.	Truck Type	Description	Injuries	Noted Defects	Other Defect	Notes On Defects/Probable Cause
121	81 Kwrth. 3-axle w/ tanker	Left front tire failed, causing loss of control	1 fatality, 1 injury	Tires	*	Records at the carrier showed the blown tire had about 90,000 miles on it. Measurements showed about 10/32 inch of tread. NTSB states the explosive failure of the truck's steering axle tire as probable cause.
172	66 White Sraight truck w/ loaded flatbed	Truck blew a tire and then ran off the road	0	Tires	*	No measurements are recorded for the tire in this accident. NTSB states the explosive failure of the truck's steering axle tire as probable cause.
49	86 Freightliner COE w/ 2 loaded 27 ft van trilers	While travelling down a 3% grade on a wet grooved surface, driver noticed trailer moving to the left. Attempts to straighten vehicle caused loss of control. Rear trailer rolled.	*	Tires	*	The two-axle power unit had at least 10/32 in. of tread on the steering axle tires. The drive-axle tires had only 2/32 in.on rt. and 5/32 in. on left. NTSB states failure of driver to maintain control, wet surface and tires as probable cause.
79	85 Ptrblt. w/ 45 ft van trailer	Pick up truck slid on ice and struck rear of truck	1 injury	Underride Protection	*	The distance from the outside edge of the trailer to the rear end of the protection device was in exceedance of CFR 393.86. NTSB states driver error as probable cause. Underride contributed to severity.

APPENDIX F2

Summary of
Kansas City, Missouri
Police Accident Inspection Reports

Appendix F2 contains Table F2 which list the CMV accident information obtained from Missouri. The information was utilized as part of the accident inspection database.

Table F2: Kansas City, Missouri Accident Inspection Data

State	Date	Truck Type	Accident Description	Listed Defect 1	Defect 2	Defect 3	Specific Sub-Item(s)	Other Contributing Circumstance	Injury Severity	Notes from Inspection Narrative
MO	11/15/94	74 Kwrth Straight Truck	Truck overturned while making a left turn on exit ramp	Brakes	Ball and socket joint		two brakes were 50% OOA: front ball and socket joint worn beyond 1/8"	not stated	one person	Narrative states that the OOS violations were a factor in the accident.
MO	11/29/94	76 Ford Straight Truck	Truck unable to stop for traffic at red light	Brakes	Tires		3 brakes OOA and steering axle brake inoperative: Inside axle-2 tire flat; Exceeded max. weight rating on steering tires	not stated	unknown	Narrative states that the accident was caused by the condition of the vehicle and its load.
MO	12/22/94	95 Ford Straight Truck	Truck unable to stop for traffic at red light	Brakes	Fuel System		Fuel tank strap broken: trai;er brakes inoperable: back-up power supply for E-brake away was dead	Too fast	unknown	Narrative states that the OOS violations (trailer-brakes only) were a probable cause and possibly too fast for conditions as a very heavy fog was present at the time of the accident.
MO	12/20/94	89 Frghtlnr. w/ trailer	Truck unable to stop for a stopped vehicle	Brakes	Tires	Lights	Service side air hose not connected; unable to maintain air pressure; trailer brakes inoperative; air leak at #3 axle quick release valve; brake light out; container box not secured.	not stated	yes	While narrative doesn't address that the OOS violations were a factor in the accident, the severity of the brake violations leads one to believe that they were at least a contributing factor if not the probable cause.
MO	12/13/94	87 Ford Straight truck	Truck unable to stopwhile descending a hill and overturned on corner	Brakes	Fuel System		left steering brake was contaminated; fuel tank strap was loose; 505 brakes were OOA or defective.	not stated	no	Narrative states that the driver said his brakes would not work.
MO	1/27/95	82 Mack w/ trailer	Truck unable to stop for traffic at red light	Brakes	Steering	Tires	Flat tire inside axle #3; pitman arm loose; inoperative brake axle 4; 4 brakes OOA.	not stated	yes	Narrative states that the brakes were out of adjustment and the driver could not stop for a red light.
MO	8/25/95	Int'l. w/ trailer	Truck unable to stop for a stopped vehicle	Brakes	Tires	Steering	Inside tire flat axle #3; axle 4 tire < 2/32" tread; axle 3 tire rated 75# had 12#; pitman arm loose; brake lining cracked axle #4;5 brakes OOA; axle 5 brake canister loose	not stated	yes	While narrative doesn't address that the OOS violations were a factor in the accident, the severity of the brake violations leads one to believe that they were at least a contributing factor if not the probable cause.
MO	8/28/95	82 Mack trash compactor	Truck unable to stop for traffic at red light	Brakes	Wheels	Lights	Unable to maintain air pressure; broken air line axle #3; 33% brakes OOA; cracked wheel across spoke; no operating brake lights	not stated	yes	Narrative states that the OOS violations regarding brakes (only) were a cause of the accident.

Table F2: Kansas City, Missouri Accident Inspection Data

State	Date	Truck Type	Accident Description	Listed Defect 1	Defect 2	Defect 3	Specific Sub-Item(s)	Other Contributing Circumstance	Injury Severity	Notes from Inspection Narrative
MO	9/26/95	78 Western Star Dumptruck	Truck unable to stop for traffic at red light	Brakes	Steering		Rear drag link ball joint was worn beyond 1/18" movement; brake lining on steering axle contaminated with oil; 4 of 6 brakes OOA; brake chamber diaphraghm ruptured on right side axle #2.	careless driving	yes	Narrative states that the accident was apparently due to the driver being unable to stop the vehicle. 83% of the brakes were OOA or defective. Inspector does not state wether the violations contributed to the accident.
MO	7/24/95	1987 Ford Dumptruck	Truck unable to stop for a stopped vehicle	Brakes	Lights		Two brakes were OOA ;exceeded tire weight rating on 4 tires	not stated	yes	Narrative states that the driver stated he was unable to stop the vehicle because of brakes being inoperative. Inspector does not state wether the violations contributed to the accident.
MO	8/24/95	77 Ford Straight Truck	Driver states he's unable to slow the vehicle when making a turn and rolled the truck	Brakes	Steering		Left tierod worn beyond 1/8 in.;six brakes were inoperative	not stated	yes	Narrative states that the inoperative brakes were the cause of the accident.
MO	8/8/95	86 Int'l Straight Truck	An apparent roll-away, no details given	Brakes			Parking brake was inoperative; two broken springs on the steering axle	not stated	no	Narrative states very little about the nature of the accident except to say that the accident was caused by the defective parking brake and the failure of the driver to chock the wheels.
MO	7/24/95	88 Ford Dumptruck	Truck unable to stop for a stopped vehicle	Brakes	Tires		Brakes were inoperative on steering axle (33%); exceeded max. weight rating for tires on axles # 2 and 3	truck overloaded	no	Narrative states very little about the nature of the accident. Inspector does state that the accident was caused by the overloaded condition of the truck and the inoperative brakes on axle # 1.
MO	6/29/95	80 Int'l Straight Truck	Truck unable to stop for traffic at red light	Brakes	Lights	Exhaust	No rear turn signals or brake lights; ball and socket joints worn beyond 1/8"; no low air warning; three brakes 50% OOA; brake shoe loose right side axle; contaminated brake lining axle #2; exhaust leak under cab w/ hole in floor	none stated	no	Narrative states that the OOS violations were a factor in the accident (most likely the brake violations)
MO	6/19/95	91 Mack	No narrative about the accident	Brakes			Air line on axle #1 worn to second layer of cords; six brakes (56%) were OOA	none stated	yes	Narrative states that the brake OOS violation was the cause of the accident
MO	5/2/95	88 Ford semi w/ trailer	Truck unable to stop for a stopped vehicle	Brakes	Fuel System		tank leaking fuel; 3 brakes were OOA; Axle 5 brake inoperative on right side	none stated	yes	Narrative states that the OOS violations were a factor in the accident (most likely the brake violations)

Table F2: Kansas City, Missouri Accident Inspection Data

State	Date	Truck Type	Accident Description	Listed Defect 1	Defect 2	Defect 3	Specific Sub-Item(s)	Other Contributing Circumstance	Injury Severity	Notes from Inspection Narrative
MO	9/28/95	95 Chevy w/ trailer	Trailer broke free and overturned	Coupling Device	Brakes		Breakawy device was inoperative; Unit 2 had brakes on only one axle; coupling device was defective	not stated	no	Narrative states very little about the nature of the accident except to say that the coupling device was defective, allowing unit one to seperate from unit two
MO	8/11/95	94 Mack w/ trailer	Truck had overturned while attempting a left hand turn	Safe Loading/Tiedowns	Brakes	Suspension	Load was not properly secured; broken main spring left side axle # 5; two brakes were OOA; brake lining worn to less than 1/4" axle #4	not stated	no	Narrative states that the accident was caused by the load shifting resulting in the vehicle overturning.

Missouri data taken from Kansas City, MO Police Dept. Accident Inspections October 1, 1994-September 30, 1995.

APPENDIX F3

Summary of
Maryland Commercial Vehicle Enforcement
Accident Inspection Reports

Appendix F3 contains Table F3 which lists the CMV accident information obtained from Maryland. The information was utilized as part of the accident inspection database.

Table F3: Maryland Accident Inspection Data

State	Date	Truck Type	Accident Description	Listed Defect 1	Defect 2	Specific Sub-Item(s)	Other Contrib. Circum.	Injury Severity	Notes from Inspection Narrative
MD	8/29/95	79 Kenwrth Tractor	Truck ran red light striking passenger vehicle	Brakes	none	Adjustment Limits	Failure To Yeild	one injury	The crash was driver error with brakes being OOA a contributing factor. 4 of 4 brakes were OOA.
MD	11/13/94	85 I'ntl. Cabover	Truck had lost its right rear, 5th axle, set of tires/wheels which struck another vehicle injuring four.	Wheels	Brakes	Wheel cracks	none	four injuries	Inspection found that the trailer's found 5 of 10 lug studs broken or cracked on the 5th axle. Also several audible air leaks were found.
MD	2/8/95	89 Mack w/trailer	Truck left the roadway and struck guardrail, overturning	Suspension	none	U-Bolt cracked or missing	none	none	Inspector's opinion that the broken U-bolts holding the leaf spring assembly on the left rear caused the accident to occur by shifting the weight at the rear of the truck.
MD	3/14/95	81 Ford truck w/ trailer	Truck was unable to negotiate a turn and left roadway.	Brakes	none	Brakes Inoperative	none	none	Inspector found the master cylinder empty of brake fluid though could not find evidence of leakage. Driver sated that brakes went out and that he had experienced a loss of brake fluid before.
MD	6/25/95	87 Ford Conv. w/ trailer	Truck was unable to stop for traffic, colliding with a car that started a chain reaction	Brakes	none	Adjustment Limits	Driver inattention	Two injuries	Inspector states that driverr inattention was the causative factor for the accident and that the trucks brakes being OOA was only a contributory factor.
MD	8/8/95	90 Ford Truck w/ trailer	Truck was unable to stop for traffic, colliding with a car that started a chain reaction	none	none		Overweight	Two injuries	Inspector states that due to the overloading of the truck beyond its GVWR, the braking system was limited to a longer stopping distance. States driver as causative factor for operating truck beyond its capabilities.
MD	8/16/95	88 Mack w/ trailer	Decending a grade the truck lost control and was unable to negotiate a curve	Brakes	none	Adjustment Limits	none	none	Three of four trailer brakes were OOA and six of the tractor brakes were OOA. The inspector states that the cause of the accident was driver error and that the brakes were contributory.

Table F3: Maryland Accident Inspection Data

State	Date	Truck Type	Accident Description	Listed Defect 1	Defect 2	Specific Sub-Item(s)	Other Contrib. Circum.	Injury Severity	Notes from Inspection Narrative
MD	8/30/95	79 Mack w/ trailer	Decending a grade the truck lost control when the tires blew.	Tires	none	none	Overweight	One injury	Another case of a vehicle being overweight causing a mechanical failure. Inspector states that the weight of the vehice combined with excessive speed caused recaps to fail.
MD	9/10/95	73 White Cabover	Truck had lost its tandem wheels from 5th axle left side which struck another vehicle.	Wheels	none	none	none	1 injury and 1 fatality	The inspectors opinion states that the inner grease seal of the hub had been leaking fluid causing the bearings to eventually become hot damaging the spindle and eventually shearing the tandem wheels.
MD	9/15/95	89 Ford Aeromax L9000 w/trailer	Truck had lost its tandem wheels from 5th axle left side which struck another vehicle.	Wheels	none	none	none	none	The inspectors opinion states that the inner grease seal of the hub had been leaking fluid causing the bearings to eventually become hot damaging the spindle and eventually shearing the tandem wheels.
MD	9/28/95	88 Peterbilt w/ trailer	Truck was unable to slow for merging traffic resuting in collision	Brakes	none	Adjustment Limits	none	4 injuries	5 of 6 brakes were OOA on tractor and 3 of 4 were OOA on trailer. The fact that the trailer was fully loaded combined with the decreased braking efficiency were the cause of the accident.
MD	3/14/95	86 White w/ trailer	Truck was unable to stop for stopped/slowed traffic.	Brakes	none	Brakes Inoperative Adjustment Limits	none	5 injuries	With 8 of 10 brakes OOA or inoperative the vehicle 's stopping efficiency was greatly impaired.
MD	1/31/94	89 Frghtlnr. w/ trailer	Truck was unable to stop for slowed traffic.	Brakes	none	Adjustment Limits	driver inattention	one injury	Inspector suspects driver fatigue was causative factor. The truck had 8 of 10 brakes OOA and the vehicle's stopping efficiency was mpaired, though this is listed as a contributory factor.

Table F3: Maryland Accident Inspection Data

State	Date	Truck Type	Accident Description	Listed Defect 1	Defect 2	Specific Sub-Item(s)	Other Contrib. Circum.	Injury Severity	Notes from Inspection Narrative
MD	10/4/94	84 Ptrblt. w/ trailer	Driver applied brakes for unknown reason and jackknifed into right barrier wall and was ejected.	Brakes	none	Brakes Inoperative Brake Lining	driver error	1 fatal	Inspector suspects driver's actions as a causative factor. The truck had several brake violations. Specifically, the left steering brake was contaminated with oil and was listed as inoperative causing the truck to swerve violently and crash.
MD	9/6/94	84 Ford CL 9000	Truck was unable to negotiate a turn and left the roadway, overturning.	Brakes	none	Adjustment Limits	none	1 injury and 1 fatality	The brake violations on truck and tractor were numerous, mostly push rod stroke in exceedance of recommended settings. Inspector states the condition of the vehicle as contributory.
MD	4/4/94	80 GMC w/ trailer	Driver lost control of vehicle and shifted his losd causing vehicle to overturn	Brakes	Suspension	Brake Lining Leaf Spring Missing	driver error	2 injuries	Inspector states that the drivers speed and loss of control caused the accident. The load shifting was a result of the accident and the load was properly secured. Brakes and suspension contributed.
MD	5/23/94	89 Ptrblt. w/ trailer	Truck was unable to stop for slowed traffic causing an eight car collision.	Brakes	none	Adjustment Limits	driver error	several	Inspector states that the primary cause of the accident were the vehicle defects which were 5 of 6 brakes on the tractor being out of adjustment.
MD	6/17/94	89 Mack w/ trailer	truck hit a bump and broke the lower frame rail which split the cargo wall, causing load to spill out of the bottom of the trailer.	Van and Open Top Trailer Bodies	none	Broken lower rail	none	none	Inspector found the left side lower rail of the trailer cracked in three different places (82 freauhauf trailer). It was his opinion that this caused the trailer to fail and spill its load.
MD	6/20/94	84 Ford w/ Tanker	Truck was hauling waste oil in a straight truck/tanker when vehicle lost control due to product shifting	Other	none		none	one injury	Inspector stated that the tank's U-Bolts that fixed the tank to the truck had been severed. One of them appeared rusted and had broke prior to the accident. States that the oil shifting in the loose tank caused loss of control.

Table F3: Maryland Accident Inspection Data

State	Date	Truck Type	Accident Description	Listed Defect 1	Defect 2	Specific Sub-Item(s)	Other Contrib. Circum.	Injury Severity	Notes from Inspection Narrative
MD	7/6/94	84 Kenwrth Tractor w/ trailer	Truck was unable to stop for slowed traffic causing an eight car collision.	Brakes		Brakes Inoperative Adjustment Limits	driver error	2 fatals and 2 injured	The inspector in this case found many of the brakes in the at-fault truck to be inoperable or OOA but fails to place the causation with the vehicle. Conclusion was drawn that the driver was at fault for driving an unsafe vehicle.
MD	8/1/94	80 Mack R600	Tires failed while truck was making a left turn which and rolled the truck	Coupling Devices	none	Fifth Wheel	driver error	none	Inspector states that driver speeding around the turn was the causative factor resulting in undue stress to the tires. The lower fifth wheel broke loose at this point causing the rollover, a result of broken welds holding the fifth wheel to the frame.
MD	8/25/94	78 GMC 6500	Truck ran red light striking passenger vehicle	Brakes	none	General maintenance	driver error	one injury	Inspector states that the hydraulic brake system's deficiencies were a contributing factor
MD	8/22/94	89 Int'l	Truck was unable to stop when descending a grade and struck another vehicle	Brakes	none	Brakes Inoperative Adjustment Limits	driver error	1 injury and 1 fatality	Driver apparently knew he was overweight and attempted to bypass weigh station taking an alternative, steeper route that was not passable for a truck in its condition. 2 of 6 brakes werere OOA and brake linings were cracked with voids and missing segment

APPENDIX F4

Summary of
Maine State Police
Accident Inspection Reports

Appendix F4 contains Table F4 which lists the CMV accident information obtained from Maine. The information was utilized as part of the accident inspection database.

Table F4: Maine Accident Inspection Data

State	Date	Truck Type	Accident Description	Listed Defect 1	Defect 2	Specific Sub-Item(s)	Other Contributing Circumstance	Injury Severity	Notes from Inspection Narrative
ME	3/27/89	86 I'ntl	Truck was unable to stop for stopped/slowed traffic.	Brakes		Brakes Inoperative/ OOA	Inattention	1 fatal, 3 injuries	Inspectors opinion that the inattention of the driver and the condition of the brakes were the causative factors in the accident. Virtually no braking ability in all of the tandems on the trailer unit, and left front brake grabbed at shorter distance.
ME	3/23/89	79 Ford 3 axle truck w/ trailer	Truck was unable to stop for stopped/slowed traffic.	Brakes		Brakes Inoperative/ OOA	none	1 fatal, 1 injury	Inspector states that the primary causation factor was the inadequate brakes on the truck. Numerous rusted drums and brakes shoes and push rods that were in their fully extended position.Oil contamination in brakes.
ME	10/25/91	76 Frghtlnr. tractor w/ trailer	Truck changed lanes and struck the rear of a passenger vehicle which roteted in front of truck and was subsequently dragged and crushed.	Suspension	Brakes	Broken U-bolts and leaf springs Brakes Inoperative/ OOA	none	2 fatal, 1 injury	Inspector states that loose U-bolts and the broken lead springs caused a steering action that initiated and compounded this accident.Ineffective braking ability due to lack of front brakes and inopertive or OOA brakes on the trailer increased the severity
ME	11/26/91	GMC tractor w/ trailer	Truck was unable to negotiate a turn and left the roadway, overturning.	Brakes		Brakes Inoperative/ OOA	Inattention	1 fatal	Inspector states driver error as cause of accident with brakes contributing . Both steering axle brakes were inoperative (adjustment screws backed off completely). Brakes OOA on front drive axle.
ME	12/4/91	88 GMC	Truck was unable to stop for train and was broadsided. Train derailed crushing truck.	Brakes		Brakes Inoperative/ OOA	Unknown	1 fatal, 2 injuries	Inspector does not state the cause of the accident but alludes to the fact that the braking efficiency of the truck was greatly diminished with 67% of the brakes OOA or inoperative.

APPENDIX F5

Summary of
Colorado State Patrol
Accident Inspection Reports

Appendix F5 contains Table F5 which lists the CMV accident information obtained from Colorado. The information was utilized as part of the accident inspection database.

Table F5: Colorado Accident Inspection Data

State	Date	Truck Type	Accident Description	Listed Defect 1	Defect 2	Specific Sub-Item(s)	Other Contributing Circumstance	Injury Severity	Notes from Inspection Narrative
CO	2/25/93	1990 IHV w a van trailer	Decending a grade the truck lost control and was unable to negotiate a curve	Brakes	none	adjustment limits, brakes inoperative(brake switch was off).	none stated	unknown	Inspector found "most" of the brakes to be OOA. Eight brakes were inspected and only one was withinn adjustment limits.. Upon checking the cab, inspector found the engine brake switch in the off position.
CO	5/14/93	87 White w/trailer	Truck was unable to stop for a car that was attempting a U-turn in front of it.	Brakes	none	lack of hydraulic fluid (brakes inoperative), brakes contaminated	none	1 fatality	Inspector found 50% of the brakes to be OOA. The left brake lining on the steering axle was beloew limits. Inspector states brakes as a possible contributing factor.
CO	5/25/93	81 Ford w/ trailer	Decending a grade the truck lost control and was unable to negotiate a curve	Brakes	Tires	adjustment limits, brakes inoperative, tires worn beyond acceptable limits	inexperience	2 fatalities	Inspector found rear axle brakes to be inoperative because of OOA limits. Rt. front trailer axle brake was OOA. Two tires were worn to exposed limits. One tire had blown prior to accident. Inspector states poor mechanical cond.as a contrib. circumstance.
CO	5/26/93	GMC 3-Axle w/ rock trailer	Truck was unable to negotiate a turn and left the roadway, overturning.	Brakes	none	lack of hydraulic fluid (brakes inoperative), brakes contaminated	none	1 injury	Inspector found steering axle brakes and one trailer brake to be OOA.
CO	6/29/93	61 Int'l w/ drilling rig	Truck was unable to negotiate a turn and left roadway.	Brakes	Steering	brakes inoperative, adjustment limits, ball and socket joints were loose, all steering linkage was loose	none	1 fatality	Front axle not equipped with brakes, one brake on axle 2 was OOA, and axle 3 brakes inoperative. Brake drum on axle two was broken. Steering box was loose on the frame, pitman arm was loose from output shaft. Ball and socket loints were also loose.
CO	7/8/93	90 Ptrblt. w/ trailer	Truck was unable to stop for traffic, colliding with a car that started a chain reaction	Brakes	none	brake adjustment limits	none	none	All of the brakes on axles 1,3,4, and 5 were OOA. No statement on inspector's report about contributing circumstances though the attatched accident report states inoperatve brakes as a contributing factor

Table F5: Colorado Accident Inspection Data

State	Date	Truck Type	Accident Description	Listed Defect 1	Defect 2	Specific Sub-Item(s)	Other Contributing Circumstance	Injury Severity	Notes from Inspection Narrative
CO	9/14/93	Kwrth w/ trailer	Truck was unable to stop for traffic, colliding with a car that started a chain reaction	Brakes	none	brake adjustment limits	inattention	one probable, one evident	4 of 10 brakes were OOA, the steering axle (a wedge brake) had 1/8 in. of clearance, where a proper adjustment would be no more than 1/16th in. Three brakes on axles 2 and 3 were OOA. Grease in drum of front drive axle.
CO	10/29/93	93 frghtnr w/ loaded trailer	Truck was unable to negotiate a turn and left roadway.	Brakes	none	brake adjustment limits	none	1 injury, several cattle dead	The only major defect found by the inspector was that the trailer brakes were all OOA. In his opinion this could have contributed the accident.
CO	1/10/94	82 Int'l 4300	Truck was unable to stop for four-way stop sign, colliding with another truck	Brakes	none	adjustment limits, grease contamination of brake drum	none	1 injury	Both steering axle brakes contaminated with grease, diaphraghm leakin on front axle parking brake, 4 brakes were OOA.
CO	3/29/94	79 Ptrblt. w/ trailer	Truck was unable to stop for car making a left from oncoming traffic and struck the vehicle.	Brakes	none	adjustment limits, grease contamination of brake drum, brakes inoperative	none	2 fatalities, 1 injury	Inspector found two brakes # 4 axle to be OOA. One brake on axle 3 was inoperative, and drum on axle 2 was contaminated with grease.
CO	6/17/94	84 Kwrth. w/ trailer	Decending a grade the truck lost control and was unable to negotiate a curve	Brakes	none	adjustment limits, grease contamination of brake drum	none	unknown	Inspector found all of the brakes except one to be OOA. The left steering brake was contaminated with grease. An air leak was also discovered on axle 3. Jake brake was inoperative. No accompaning accident report.
CO	8/23/94	86 Frghtlnr. w/ trailer	Truck was unable to negotiate a turn and left the roadway, overturning.	Brakes	none	lack of hydraulic fluid (brakes inoperative), brakes contaminated	inexperience	3 injuries	Inspector found all the brakes on the tractor to be OOA. The brake on axle 2 rt.side was not working with the brake drum rusted. Axle 3 brakes were also inoperative due to OOA levels. Accident report states brakes as a contributing circumstance.

Table F5: Colorado Accident Inspection Data

State	Date	Truck Type	Accident Description	Listed Defect 1	Defect 2	Specific Sub-Item(s)	Other Contributing Circumstance	Injury Severity	Notes from Inspection Narrative
CO	8/25/94	84 Mack	Truck was unable to negotiate a turn and left the roadway, overturning.	Brakes	none	lack of hydraulic fluid (brakes inoperative), brakes contaminated	inexperience	none	Inspector found rear brakes to be inoperative, the left rear brake was contaminated with brake fluid and the fluid level was low. Accident report states brakes as a contributing circumstance.
CO	12/20/94	77 Frghtlnr.Cabover w/ trailer	Truck collided with a farm implement travelling down the road at a reduced speed.	Brakes	none	brake adjustment limits, brake tubing/hose	inattention	1 fatality, 1 injury	4 of 6 brakes were OOA. One tire had insufficient tread, and the drag link was showing excessive play at its connection to the steering arm. Semi was losing considerable air w/ the engine running.
CO	6/7/95	82 Frghtlnr. w/ trailer	Truck was unable to negotiate a turn and left roadway.	Brakes	none	brake adjustment limits, grease contamination, leaking air diaphraghm	none	1 injury	The tractor and trailer had 6 of 10 brakes OOA. The tractor had a brake saturated with oil from a leaking wheel seal on the left rear driver. Broken diaphraghm in the air chamber on rt. front steering axle.
CO	11/31/94	77 Int'l. Loadstar w/ trailer	Truck was unable to negotiate a turn and left the roadway, overturning.	Brakes	none	lack of hydraulic fluid (brakes inoperative), brakes missing	none	1 fatality	Master cylinder was empty on hydraulic brake system and no evidence of leaking at the accident site. Rear brake cylinder showed signs of leakage prior to accident. No brakes on the trailer at all. Inspector states as probable cause the lack of brakes.
CO	1/14/93	1980 Peterbilt	Truck did not have fifth wheel properly engaged and lost its trailer while rounding a curve	Coupling Devices	none	Kingpin not properly engaged	none stated	unknown	Inspector found that the cause was the driver not engaging the kingpin properly into the fifth wheel plate. Kingpin jumped out of the locking ring and the trailer came loose and rolled. Some propaane was lost as a result.
CO	5/4/93	80 Kwrth. w/ trailer	Truck broke its kingpin from the trailer and and lost its trailer while rounding a curve	Coupling Devices	none	Kingpin cracked	none	none	Inspector found the fifth wheel trailer pin (kingpin) had broken out of the fifth wheel plate and allowed thre trailer to become seperated from the tractor. The fifth wheel plate had several cracks in it and a almost perfect circle around kingpin.

Table F5: Colorado Accident Inspection Data

State	Date	Truck Type	Accident Description	Listed Defect 1	Defect 2	Specific Sub-Item(s)	Other Contributing Circumstance	Injury Severity	Notes from Inspection Narrative
CO	5/7/93	81 Intl Cabover w/trailer	Truck lost its rear axle on the trailer, spilling load	Frame	none	Trailers subframe retainer blocks	none	none	Inspector found the retainer blocks (unable to locate this in the OOSC) on the slider frame had sheared the bolts and the axles on the trailer ad come out from under trailer.
CO	2/12/93	87 Kwrth. COE w/ flatbed	No description of accident given	Lighting Devices	none	Trailer sidemarker lights were inoperative, as were the rear stop lights.	none stated	unknown	Inspector states the sidemarker lights on the right side in the middle and rear of the trailer were not working. Also the left sidemarkernear the rear was not working. Rear stop lights on trailer were inoperative. States lights as contributing factor.

APPENDIX G

Additional Sources Results

Appendix G contains Table G1 which lists the observed occurrences for specific defects for the 1976-1978 MCS database, 1993-1994 GES database, and the accident inspection databases.

Table G1: Additional Sources Data by Specific Defect

	Source	1976-78 DOT MCS		1993 & 1994 GES		Accid. Investigation	
	Sample Size	89,602		643,840		Unknown	
Defect Category	Specific Defect	Total Observed	% of Category	Total Observed	% of Category	Observed Occu-rences	% of Category
Accessories	Guages (all)	2	7.14%				
Accessories	Horn	1	3.57%				
Accessories	Hydraulic lift	2	7.14%				
Accessories	Other or unknown	10	35.71%	13	41.94%		
Accessories	Speedometer	6	21.43%				
Accessories	Windshield wiper control	7	25.00%	18	58.06%		
Sum		**28**	**100.00%**	**31**	**100.00%**	**0**	
Axle	Adjustable	55	61.80%				
Axle	Axle shaft broken	18	20.22%				
Axle	Fell off	0	0.00%				
Axle	Multi-speed mechanisms	1	1.12%				
Axle	Non-drive	9	10.11%				
Axle	Other or unknown	6	6.74%				
Sum		**89**	**100.00%**	**0**		**0**	
Body	Battery casing						
Body	Cab doors	1	1.06%				
Body	Cargo box, van	4	4.26%				
Body	Cargo doors, trailer body panels, floor, etc.	14	14.89%				
Body	Cargo heater or refrigeration unit	4	4.26%				
Body	Cargo tank	8	8.51%				
Body	Distance from end of trailer to protection device exceeded.	0	0.00%			1	33.33%
Body	Hold-down latch or tilting mechanism	13	13.83%				
Body	Interior	3	3.19%				
Body	Other or unknown	4	4.26%				
Body	Rear load ramp height	0	0.00%			1	33.33%
Body	Spare tire rack	23	24.47%			1	33.33%
Body	Trailer support (landing gear)	20	21.28%				
Sum		**94**	**100.00%**	**0**		**3**	**100.00%**
Brakes	121 brake system	80	6.07%				
Brakes	Adjustment	0	0.00%			53	49.53%
Brakes	Air Chambers (Diaphragm)	35	2.66%			4	3.74%
Brakes	Air or vacuum booster	3	0.23%				
Brakes	Air Valve	7	0.53%			3	2.80%
Brakes	Brake linings contaminated	0	0.00%			13	12.15%
Brakes	Check valve	1	0.08%				
Brakes	Compressor	8	0.61%				
Brakes	Couplings (glad hands, etc.)	14	1.06%				
Brakes	Cracked lining	0	0.00%			2	1.87%
Brakes	Cylinder seal	0	0.00%			4	3.74%
Brakes	Disconnected	0	0.00%			1	0.93%
Brakes	Drums	0	0.00%			4	3.74%
Brakes	Hydraulic pump or accumulator	3	0.23%				
Brakes	Improper installation	0	0.00%			2	1.87%
Brakes	Lines	102	7.74%			7	6.54%
Brakes	Lining wear	0	0.00%			1	0.93%

Table G1: Additional Sources Data by Specific Defect

	Source	1976-78 DOT MCS		1993 & 1994 GES		Accid. Investigation	
	Sample Size	89,602		643,840		Unknown	
Defect Category	Specific Defect	Total Observed	% of Category	Total Observed	% of Category	Observed Occu-rences	% of Category
Brakes	Linings, shoes, fasterners, drum, clevis pin	17	1.29%				
Brakes	Low air or vacuum indicator	2	0.15%				
Brakes	Master cylinder	1	0.08%				
Brakes	Other or unknown	785	59.56%	6,487	100.00%	12	11.21%
Brakes	Parking brake	121	9.18%			1	0.93%
Brakes	Pedal, foot valve	17	1.29%				
Brakes	Pressure relief valve	29	2.20%				
Brakes	Springs, cams, adjusters, actuator valve	83	6.30%				
Brakes	Wheel cylinder	10	0.76%				
Sum		**1,318**	**100.00%**	**6,487**	**100.00%**	**107**	**100.00%**
Cooling system	Belt water pump	2	13.33%				
Cooling system	Hoses, clamps, cap, thermostat, shutters	5	33.33%				
Cooling system	Other or unknown	4	26.67%				
Cooling system	Radiator	4	26.67%				
Sum		**15**	**100.00%**	**0**		**0**	
Coupling	Breakaway device	0	0.00%			1	16.67%
Coupling	Fifth wheel	57	27.94%				
Coupling	Fifth wheel kingpin	32	15.69%			1	16.67%
Coupling	Fifth wheel plate	12	5.88%			1	16.67%
Coupling	Locking and Release mechanism	43	21.08%			1	16.67%
Coupling	Mounting, welds, u-bolts	5	2.45%				
Coupling	Not properly engaged	0	0.00%			1	16.67%
Coupling	Other or unknown	33	16.18%	1,060	100.00%	1	16.67%
Coupling	Pintle Hook	8	3.92%				
Coupling	Saddle mount	3	1.47%				
Coupling	Spindle broken	0	0.00%				
Coupling	Tow bar, ball & socket, etc.	11	5.39%				
Sum		**204**	**100.00%**	**1,060**	**100.00%**	**6**	**100.00%**
Driveline	Carrier bearings	1	3.57%				
Driveline	Differential failure	2	7.14%				
Driveline	Fell out (part or all)	0	0.00%				
Driveline	Other or unknown	6	21.43%	308	100.00%		
Driveline	Shaft broke	17	60.71%			1	100.00%
Driveline	Universal joints	2	7.14%				
Sum		**28**	**100.00%**	**308**	**100.00%**	**1**	**100.00%**
Electrical	Battery, cables	12	8.45%				
Electrical	Fuses, circuit breakers	5	3.52%				
Electrical	Generator, alternator, voltage regulator	1	0.70%				
Electrical	Ingnition system	6	4.23%				
Electrical	Instruments, controls	12	8.45%				
Electrical	Lights, brake	0				1	25.00%
Electrical	Lights, head	38	26.76%	115	9.40%		
Electrical	Lights, other	26	18.31%	110	8.99%		
Electrical	Lights, reverse	0					
Electrical	Lights, tail	0				3	75.00%
Electrical	Lights, turn and hazard	7	4.93%	999	81.62%		
Electrical	Other or unknown	24	16.90%				

Table G1: Additional Sources Data by Specific Defect

	Source	1976-78 DOT MCS		1993 & 1994 GES		Accid. Investigation	
	Sample Size	89,602		643,840		Unknown	
Defect Category	Specific Defect	Total Observed	% of Category	Total Observed	% of Category	Observed Occu-rences	% of Category
Electrical	Wiring (Cargo area)	8	5.63%				
Electrical	Wiring (power unit)	21	14.79%				
Sum		**142**	**100.00%**	**1,224**	**100.00%**	**4**	**100.00%**
Engine	Air blower	3	2.31%				
Engine	Crankshaft, internals	1	0.77%				
Engine	Flywheel, vib. dampener	2	1.54%				
Engine	Oil pump, lube system	16	12.31%				
Engine	Other or Unknown	101	77.69%				
Engine	Timing gear	2	1.54%				
Engine	Valve train	5	3.85%				
Sum		**130**	**100.00%**	**0**		**0**	
Exhaust	Exhaust pipe, hangers	1	2.86%				
Exhaust	Other or unknown	4	11.43%				
Sum		**5**	**14.29%**	**0**			
Frame	Cross members	2	5.71%				
Frame	Other or Unknown	10	28.57%				
Frame	Rails and reinforcement	22	62.86%			1	33.33%
Frame	Rivots, bolts, welds	1	2.86%			1	33.33%
Frame	Stabilizer Bars	0	0.00%			1	33.33%
Sum		**35**	**100.00%**	**0**		**3**	**100.00%**
Fuel System	Carburator	8	6.06%				
Fuel System	Fuel filters	2	1.52%				
Fuel System	Fuel lines, valves	30	22.73%				
Fuel System	Fuel pump	5	3.79%				
Fuel System	Fuel tank	5	3.79%				
Fuel System	Injection pump	2	1.52%				
Fuel System	Other or unknown	42	31.82%				
Fuel System	Throttle linkage	38	28.79%			1	
Sum		**132**	**100.00%**	**0**		**1**	**100.00%**
Load Securement	Baffles (cargo tank)	0	0.00%			1	25.00%
Load Securement	Battery casing fell off	0	0.00%				
Load Securement	Bolts holding tank failed	0	0.00%			1	25.00%
Load Securement	Bracing (metal rolls)	0	0.00%			1	25.00%
Load Securement	Other or Unknown	0	0.00%			1	25.00%
Load Securement	Part of load fell out	0	0.00%				
Load Securement	Tie downs, chains, etc.	15	100.00%				
Sum		**15**	**100.00%**	**0**		**4**	**100.00%**
Other or Unknown				6,891	100.00%		
Sum				**6,891**	**100.00%**	**0**	
Steering	Ball & socket	0	0.00%			2	40.00%
Steering	Disconnected from box	0	0.00%				
Steering	gear	29	10.78%				
Steering	linkage, drag link, tie rod	40	14.87%			1	20.00%
Steering	Other or unknown	117	43.49%	446	100.00%		
Steering	power steering system	64	23.79%				
Steering	Steering box loose	0	0.00%			1	20.00%
Steering	Steering wheel, column shaft	19	7.06%				
Steering	Tie rod (loose)	0	0.00%			1	20.00%
Sum		**269**	**100.00%**	**446**	**100.00%**	**5**	**100.00%**
Suspension	Air bags, controls, piping	8	4.49%				
Suspension	Arms, torque, rods, walking beams	18	10.11%				

Table G1: Additional Sources Data by Specific Defect

	Source	1976-78 DOT MCS		1993 & 1994 GES		Accid. Investigation	
	Sample Size	89,602		643,840		Unknown	
Defect Category	Specific Defect	Total Observed	% of Category	Total Observed	% of Category	Observed Occu-rences	% of Category
Suspension	Bushings, pivots, bearings	2	1.12%				
Suspension	Other or unknown	38	21.35%	283	100.00%		
Suspension	Shackle, pin, hanger	61	34.27%				
Suspension	Shocks and mountings	2	1.12%				
Suspension	Spring	7	3.93%			2	50.00%
Suspension	Torsion bars, stabilizer, mountings	26	14.61%				
Suspension	U-bolts holding spring	16	8.99%			2	50.00%
Sum		**178**	**100.00%**	**283**	**100.00%**	**4**	**100.00%**
Tires	Blowout	712	51.52%			2	16.67%
Tires	Low pressure	0	0.00%			3	25.00%
Tires	Original tread	378	27.35%				
Tires	Other or unknown	284	20.55%	5,850	100.00%		
Tires	Overloaded	0	0.00%			4	33.33%
Tires	Recap or retread	6	0.43%				
Tires	Sidewall separation	0	0.00%			1	8.33%
Tires	Tread low	0	0.00%			2	16.67%
Tires	Tread separation	0	0.00%				
Tires	Tube, or tube valve	2	0.14%				
Sum		**1,382**	**100.00%**	**5,850**	**100.00%**	**12**	**100.00%**
Transmission	All auxiliary failures	2	3.39%				
Transmission	Automatic tran. internal	3	5.08%				
Transmission	Clutch	4	6.78%				
Transmission	Clutch linkage	12	20.34%				
Transmission	Manual tran. internal	3	5.08%				
Transmission	Other or Unknown	16	27.12%				
Transmission	Shift controls & linkage	19	32.20%				
Sum		**59**	**100.00%**	**0**		**0**	
Wheels	Leaking grease	0	0.00%			2	66.67%
Wheels	Other of Unknown	147	61.76%	538	100.00%		
Wheels	Rims, flang, ring, hub, fasteners	25	10.50%				
Wheels	Studs, lugs, fasteners	26	10.92%			1	33.33%
Wheels	Wheel bearings	36	15.13%				
Wheels	Wheel hubs	3	1.26%				
Wheels	Wheel spacer	1	0.42%				
Sum		**238**	**100.00%**	**538**	**100.00%**	**3**	**100.00%**
		4,370		23,118		153	

APPENDIX H

State Accident Population Sources

Appendix H contains Table H1 which lists the sources for individual state CMV accident population figures.

Table H1: Sources for State CMV Accident Population Figures

State	1993 POP	1994 POP	Combined	Categories	Contact
Alabama	9,636	10,664	20,300	Truck tractor, Other truck	Bill Sharks
Alaska			0		
Arizona	5,099	5,296	10,395	Truck or truck tractor (excl. P/U), Truck tractor and semi-trailer, Other truck combination.	Don Bui
Arkansas	4,057	4,471	8,528	2-unit truck (18 whls), Multi-unit truck (dbl. bottom), Truck tractor only, Single unit truck	Mike Selig
California	31,897	33,791	65,688	Truck with trailers, Trucks w/o trailers	Michael Duran
Colorado			0		
Connecticut	4,873	5,501	10,374		
Delaware	1,150	1,063	2,213		
Florida	11,505	11,787	23,292	Medium truck, Heavy truck, Truck tractor	Cathy English
Georgia	21,333	15,386	36,719	Truck tractor (tri-axle), Tractor trailer, Other truck, Logging truck	Accident Reporting
Hawaii			0		
Idaho	1,599	1,387	2,986		
Illinois	15,869	15,394	31,263	Semi truck	Chris Trame
Indiana	21,766	26,381	48,147		
Iowa	4,565		4,565		
Kansas	2,501	2,309	4,810	Heavy trucks	Jim Schaller
Kentucky	10,366	9,446	19,812	Trucks	Jerry Pigmah
Louisiana	6,758	5,830	12,588		
Maine	2,340	2,371	4,711		
Maryland	11,693	11,680	23,373		
Massachusetts			0	Sorting by trucks not possible	
Michigan	19,139	16,152	35,291	Over 10,000, Over 2600, Buses	Judy Snow
Minnesota	4,931	5,312	10,243	Two axle six tire, Three or more axle single unit truck, Single unit truck with trailer, Truck tractor with no trailer, Truck tractor with semi-trailer, Truck tractor with triple trailers, Heavy truck of unknown type.	Lisa Peterson
Mississippi	6,217	6,708	12,925	Trk/trk tractor, Trk & semi, Other trk combo	Ron Sennett
Missouri	10,953	10,819	21,772		
Montana	1,041	738	1,779	Truck/truck tractor (w/ or w/o trailer)	Curt Rissmans
Nebraska		1,295	1,295		
Nevada		226	226	Single unit truck (two axles), Single unit truck (+ two axles), Truck/trailer, Truck/tractor (bob-tail), Tractor/semi-trailer, Tractor/double, Tractor/triple, Unknown truck.	Terry Shaw

Table H1: Sources for State CMV Accident Population Figures

State	1993 POP	1994 POP	Combined	Categories	Contact
New Hampshire	367	413	780	Single unit truck (two axles), Single unit truck (+ two axles), Truck/trailer, Truck/tractor (bob-tail), Tractor/semi-trailer, Tractor/double, Tractor/triple, Unknown truck.	Paul Davis
New Jersey	9,991		9,991	Truck combo (8'x48'), Truck combo (8.5'x48'), Truck combo (8'x48+'), Truck combo (8.5'x48+'), Truck combo double bottom, Truck.	Gerry Murphy
New Mexico	1,808	1,825	3,633	Semi	Juliet Rubio
New York	725	762	1,487	2, 3, or 4 Axle single unit truck, 1, 2, or 3 Axle trailer with 2 axle truck, 2 or 3 Axle trailer w/ 3 axle truck, Tractor and double trailer, Other combinations.	Janice McGowty
North Carolina	7,959	8,805	16,764	Truck 3 axles, Tractor and semi-trailer, Truck and trailer, Bob-tail	NC Traffic Facts
North Dakota	799	774	1,573		
Ohio	16,198	15,685	31,883		
Oklahoma	3,393	3,458	6,851		
Oregon	2,601	2,327	4,928	Truck tractor, Tractor w/ 1 trailer, Tractor with 2 trailer, Tractor w/ 3 trailer, Single unit truck, Single unit truck w/ trailer	Jim S
Pennsylvania	6,102	8,252	14,354	All vehicles 10,000+ (excluding buses)	Vincent Babich
Rhode Island			0	Sorting by trucks not possible	
South Carolina	10,997	12,202	23,199		
South Dakota	120	138	258	Straight Truck, Straight truck w/ trailer, Truck tractor only, Tractor w/ semi-trailer, Tractor w/ 2 or more semi-trailers	Pat Winters
Tennessee			0		
Texas	19,923	21,714	41,637	10,000+ GVW, Buses, Hazmat transporter	Debra Vermillion
Utah	1,759	1,750	3,509		
Vermont	523	476	999	Truck (elec, teleph, rubbish, logging, flatbed, tanker, box, dump, other), Tractor trailer (box, double, flat, tank, dump, log, car, other)	Laurie Roberts
Virginia	9,086	10,434	19,520	Truck, Semi, Semi tractor, Semi trailer	Carlin Kendrick
Washington	6,029	6,590	12,619		
West Virginia	4,165	3,908	8,073		
Wisconsin	9,028	9,935	18,963	Large truck	Eileen Schnapp
Wyoming	1,510	1,216	2,726		